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Vol. 9, No. 6, pp. 253-340, 7 text-figures September 14, 1912

THE OCCURRENCE AND VERTICAL DISTRIBUTION OF THE COPEPODA OF THE SAN DIEGO REGION

WITH PARTICULAR REFERENCE TO NINETEEN SPECIES

BY
CALVIN O. ESTERLY

UNIVERSITY OF CALIFORNIA PRESS
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This paper is the second from the Marine Biological Station at La Jolla dealing with the distribution of plankton animals. The first is that by Michael (1911) which contains data for certain hauls that will be used by later writers. It is proposed, accordingly, to refer to that paper when it gives the data for any hauls used in this one. Michael and I made no attempts to use the same hauls, and for various reasons our lists are somewhat different. In a good many cases, however, we worked over the same collections, and where that is true I have stated where the data for those hauls may be found in Michael's paper. On account of its earlier appearance, Michael's paper does not cover so many of the collections made by the station as does mine.

I have followed the plan originated by Michael and arranged the data in four sections, the surface hauls being tabulated first, those with the horizontal closing nets second, then the hauls with vertical closing nets and last those with open vertical nets. Temperatures and salinities are given for surface hauls only, but one may gain some idea of the general relation between depth, temperature and salinity from McEwen (1910).

The various nets used in collecting are referred to in the tables by letters, as follows:

A. Surface net of 000 XX mesh silk bolting cloth; the orifice of the net being 97.5 cm. in diameter.

B. The Kofoid horizontal closing net, the material the same as above, the orifice of the net being 37.5 cm. in diameter.

C. The "small" Nansen net, of 1 XX silk bolting cloth, the orifice about 45 cm. in diameter.

D. The "large" Nansen, of the same mesh as net C, but the orifice 109.5 cm. in diameter.

E. A Nansen net of 0 XX bolting cloth, the orifice of the net 62.5 cm. in diameter.

F. The "000" Nansen, of 000 XX bolting cloth and 62.5 cm. across the mouth.

It should be noted here that in Michael's paper there has been a slight error in not distinguishing between nets C and D of the list above. He designates both nets of No. 1 silk as net C in his list, when really some of the hauls in his Tables 30 and 32 were made with the large Nansen net (D above). Since reference is made from this paper to Michael's, the following in his

list of hauls with the horizontal closing nets (Tables 30 and 31) should be noted as made with the small Nansen net:

1668, 1677, 1708, 1725, 1770, 1785, 1788, 1789, 1792, 1793, 1793, 1794, 1797, 1798, 1801, 1802, 1805, 1806, 1827, 1827, 1833, 1841.

In Tables 32 and 33 (Michael) the following hauls were made with the small Nansen:

1989, 1990, 1994, 1995, 1996, 2013, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2100, 2104, 2108, 2112, 2113.

The first of the hauls I used were made in June, 1905, and the last in August, 1911; there are none in 1907. These include practically all the collections made by the station; a few hauls have been lost, some were omitted because of lack of data. Nearly all the hauls I used were made during June, July and August, though there are some in the spring, fall and winter months. The following arrangement shows how the collections are distributed with respect to season.

TABLE 1

Distribution of hauls through the year

		Number of hauls			
Year	Month	Surface	Horizontal Closing	Vertical Closing	Vertical Open
1905	June	.....	.....	.....	5
	July	.....	.....	.....	6
	December	.....	.....	.....	1
1906	June	6	.....	.....	14
	July	8	.....	.....	17
1908	June	16	.....	.....	5
	July	15	9	.....	5
	August	2	.....	.....	.....
1909	February	1	.....	.....	.....
	June	26	28	.....	.....
	July	26	.....	.....	.....
	August	.....	54	.....	.....
	September	6	7	.....	.....
	November	4	14	.....	.....
1910	February	5	.....	7	.....
	March	15	.....	34	.....
	April	5	.....	18	.....
	August	10	.....	.....	.....
1911	June	42	.....	172	.....
	August	18	.....	69	.....

In table 2, which follows, is a list of surface hauls (net A) and the data for them. These hauls were not used by Michael. The salinity is given wherever it is known. Temperatures are in degrees centigrade, and when two temperatures are given the first is that at the beginning of the haul, the second that at the end.

TABLE 2

Data for hauls with the surface net (Net A)

Haul Number	Date	Time of day	Duration minutes	Temperature of water	Salinity of water	North Latitude	West Longitude
	1906						
1106	June 21	4:55– 5:20 a.m.	25	21°.4	.....	32° 51′.0	117° 19′.0
1119	June 25	4:57– 5:22 a.m.	25	.....	.....	32° 51′.6	117° 18′.8
1125	June 26	4:15– 4:45 a.m.	30	21°.1	.....	32° 53′.4	117° 23′.6
1137	June 27	4:50– 5:10 a.m.	20	21°.4	.....	32° 51′.5	117° 17′.6
1158	June 29	5:15– 5:50 a.m.	35	19°.9	.....	32° 51′.7	117° 17′.0
1168	June 29	6:00– 6:25 a.m.	25	20°.4	.....	32° 51′.6	117° 17′.4
1180	July 2	6:10– 6:30 a.m.	20	20°.9	.....	32° 52′.3	117° 16′.7
1190	July 3	5:10– 6:00 a.m.	50	20°.4	.....	32° 52′.6	117° 18′.8
1210	July 6	6:15– 6:45 a.m.	30	29°.4	.....	32° 51′.2	117° 17′.1
1224	July 6	7:00– 8:00 p.m.	60	.....	.....	About La Jolla	
1309	July 18	12:50– 1:15 p.m.	25	.....	.....	32° 50′.9	117° 25′.5
1321	July 19	2:20– 2:45 p.m.	25	.....	.....	32° 47′.5	117° 25′.0
1345	July 21	1:10– 1:35 p.m.	25	.....	.....	32° 52′.5	117° 26′.5
1357	July 23	11:35–12:00 a.m.	25	.....	.....	32° 52′.8	117° 21′.9
	1908						
1488	June 25	8:25– 9:15 a.m.	50	18°.6	33.630	32° 55′.2	117° 21′.4
1504	June 26	12:25–12:50 p.m.	25	20°.0	33.617	32° 38′.8	117° 29′.9
1532	July 7	9:30–10:30 a.m.	60	19°.1	.....	32° 52′.8	117° 19′.0
	1910						
2204	Aug. 14	3:00– 3:30 p.m.	30	19°.4	33.693	32° 46′.6	118° 21′.9
2207	Aug. 16	10:15–10:50 a.m.	35	20°.6	33.603	32° 23′.4	117° 24′.2
2213	Aug. 16	5:29– 6:10 p.m.	41	20°.4	33.621	32° 23′.4	117° 24′.2
2219	Aug. 16	6:20– 6:54 p.m.	34	20°.3	33.630	32° 23′.4	117° 24′.2
2224	Aug. 16	6:58– 7:07 p.m.	9	20°.3	33.630	32° 23′.4	117° 24′.2
2228	Aug. 16	8:05– 8:30 p.m.	25	20°.2	33.589	32° 23′.4	117° 21′.9
2242	Aug. 17	11:54 a.m.–12:08 p.m.	14	20°.2	33.613	32° 23′.4	117° 18′.2
2259	Aug. 17	6:56– 7:28 p.m.	32	20°.1	33.567	32° 23′.4	117° 24′.2
2264	Aug. 17	7:30– 7:56 p.m.	26	20°.0	33.540	32° 24′.2	117° 24′.2
2271	Aug. 17	8:52– 9:21 p.m.	29	19°.9	33.585	32° 23′.4	117° 21′.3

Table 2—*Continued*

Haul Number	Date 1911	Time of day	Duration minutes	Temperature of water	Salinity of water	North Latitude	West Longitude
2295	June 14	5:00– 5:40 a.m.	40	16°.9	.....	32° 22′.2	117° 21′.6
2313	June 14	6:05– 7:55 a.m.	110	16°.8	.....	32° 22′.2	117° 21′.6
2316	June 14	10:00–11:00 a.m.	60	17°.0	.....	32° 22′.4	117° 21′.2
2328	June 14	11:00–12:00 a.m.	60	17°.0	.....	32° 22′.4	117° 21′.2
2331	June 15	1:30– 2:20 a.m.	50	16°.6	.....	32° 22′.7	117° 19′.2
2343	June 15	2:35– 3:25 a.m.	50	16°.5	.....	32° 22′.7	117° 19′.2
2346	June 15	4:23– 5:07 a.m.	44	16°.7	.....	32° 22′.7	117° 19′.2
2351	June 15	5:10– 6:25 a.m.	75	16°.5	.....	32° 22′.7	117° 19′.2
2361	June 15	7:05– 8:05 a.m.	60	16°.8	.....	32° 22′.7	117° 19′.2
2365	June 15	8:20– 9:25 a.m.	65	16°.7	.....	32° 22′.7	117° 19′.2
2376	June 16	1:50– 2:30 a.m.	40	16°.9–16°.6	.....	32° 23′.5	117° 18′.0
2391	June 16	4:15– 4:45 a.m.	30	16°.8	.....	32° 23′.4	117° 18′.0
2395	June 16	4:50– 5:45 a.m.	55	16°.8–16°.6	.....	32° 23′.5	117° 18′.0
2407	June 16	5:55– 6:20 a.m.	25	16°.8	.....	32° 23′.5	117° 18′.0
2410	June 16	6:45– 7:30 a.m.	45	.....	.....	32° 23′.5	117° 18′.0
2415	June 16	8:25– 9:43 a.m.	78	17°.0	.....	32° 23′.5	117° 18′.0
2427	June 17	1:45– 2:25 a.m.	40	17°.2–17°.1	.....	32° 22′.4	117° 21′.2
2431	June 17	2:30– 4:00 a.m.	90	17°.1	.....	32° 22′.4	117° 21′.2
2442	June 17	4:35– 5:00 a.m.	25	17°.1	.....	32° 22′.4	117° 21′.2
2446	June 17	5:05– 6:10 a.m.	65	17°.0	.....	32° 22′.4	117° 21′.2
2457	June 17	6:55– 7:38 a.m.	43	16°.9	.....	32° 22′.4	117° 21′.2
2461	June 17	7:45– 8:30 a.m.	45	16°.9	.....	32° 22′.4	117° 21′.4
2473	June 17	8:55–10:00 a.m.	65	16°.9	.....	32° 22′.4	117° 21′.2
2476	June 18	2:00– 2:35 a.m.	35	17°.2–17°.1	.....	32° 22′.7	117° 19′.2
2479	June 18	2:40– 3:35 a.m.	55	17°.1–16°.9	.....	32° 22′.7	117° 19′.2
2491	June 18	3:40– 3:55 a.m.	15	17°.0	.....	32° 22′.7	117° 19′.2
2494	June 18	4:05– 4:35 a.m.	30	.....	.....	32° 22′.7	117° 19′.2
2497	June 18	4:38– 5:45 a.m.	67	17°.0–17°.5	.....	32° 22′.7	117° 19′.2
2511	June 18	6:25– 7:30 a.m.	65	17°.1–17°.3	.....	32° 22′.7	117° 19′.2
2523	June 18	4:35– 5:15 a.m.	40	17°.2	.....	32° 23′.5	117° 18′.0
2526	June 18	5:20– 6:05 a.m.	45	17°.0	.....	32° 23′.5	117° 18′.0
2539	June 18	6:10– 6:40 a.m.	30	16°.9	.....	32° 23′.5	117° 18′.0
2542	June 18	7:05– 7:30 a.m.	25	17°.1	.....	32° 23′.5	117° 18′.0
2545	June 18	7:45– 9:40 a.m.	115	17°.5–17°.3	.....	32° 23′.5	117° 18′.0
2557	June 18	10:15–10:40 a.m.	25	17°.5	.....	32° 20′.0	117° 17′.4
2564	June 21	5:00– 7:00 a.m.	120	17°.1–17°.2	.....	32° 22′.4	117° 21′.2
2571	June 22	5:35– 5:50 a.m.	15	17°.1	.....	32° 40′.0	117° 32′.0
2573	June 22	6:00– 7:18 a.m.	78	17°.1	.....	32° 40′.0	117° 32′.0

TABLE 2—*Continued*

Haul Number	Date	Time of day	Duration minutes	Temperature of water	Salinity of water	North Latitude	West Longitude
	1911						
2588	June 22	9:20–10:00 a.m.	40	17°.5	.....	32° 52′.0	117° 30′.0
2594	June 24	3:45– 4:30 p.m.	45	18°.6–18°.5	.....	32° 50′.0	118° 20′.3
2607	June 26	4:00– 5:10 a.m.	70	17°.9	.....	32° 22′.7	117° 19′.2
2620	June 26	5:45– 6:45 a.m.	60	18°–17°.9	.....	32° 22′.7	117° 19′.2
2639	Aug. 8	4:05– 5:05 a.m.	60	.....	.....	32° 23′.5	117° 18′.0
2645	Aug. 8	5:10– 5:35 a.m.	25	.....	.....	32° 23′.5	117° 18′.0
2651	Aug. 8	6:05– 6:55 a.m.	50	19°.4–19°.7	.....	32° 23′.5	117° 18′.0
2674	Aug. 8	8:45– 9:55 a.m.	70	.....	.....	32° 23′.5	117° 18′.0
2679	Aug. 8	10:17–10:38 a.m.	21	20°.4	.....	32° 23′.5	117° 18′.0
2680	Aug. 9	3:20– 4:23 a.m.	63	19°.9–19°.8	.....	32° 22′.7	117° 19′.0
2703	Aug. 9	6:06– 6:33 a.m.	27	20°.0	.....	32° 22′.4	117° 18′.5
2714	Aug. 9	7:15– 8:10 a.m.	48	19°.6–20°.0	.....	32° 22′.7	117° 19′.0
2725	Aug. 9	8:35– 9:20 a.m.	45	20°.1	.....	32° 22′.3	117° 20′.2
2736	Aug. 10	3:45– 4:53 a.m.	68	20°.8–20°.6	.....	32° 22′.4	117° 21′.2
2747	Aug. 10	5:06– 6:00 a.m.	54	20°.7	.....	32° 22′.4	117° 21′.2
2749	Aug. 10	6:12– 7:55 a.m.	103	20°.6	.....	32° 23′.3	117° 20′.0
2751	Aug. 10	8:45– 9:45 a.m.	60	20°.1	.....	32° 18′.2	117° 24′.7
2753	Aug. 10	11:35–12:45 p.m.	70	19°.8	.....	32° 18′.2	117° 24′.7
2755	Aug. 10	12:53– 1:45 p.m.	52	19°.8	.....	32° 18′.2	117° 24′.7
2756	Aug. 11	5:50– 6:40 a.m.	50	20°.4	.....	32° 20′.9	117° 21′.1
2760	Aug. 11	8:05– 9:12 a.m.	67	20°.5	.....	32° 20′.9	117° 21′.1
2761	Aug. 11	10:45–11:57 a.m.	72	20°.7	.....	32° 22′.7	117° 29′.2
2762	Aug. 11	12:46– 1:35 p.m.	51	20°.1	.....	32° 20′.0	117° 17′.4

The following is a list of the surface hauls that I used, the data for which may be found in table 28, page 79 of Michael's (1911) paper:

1432, 1436, 1438, 1444, 1448, 1452, 1452, 1455, 1460, 1465, 1471, 1478, 1499, 1509, 1512, 1530, 1559, 1560, 1562, 1568, 1579, 1582, 1585, 1588, 1591, 1594, 1597, 1600, 1605, 1634, 1650, 1653, 1655, 1657, 1667, 1673, 1680, 1682, 1686, 1689, 1695, 1698, 1703, 1712, 1716, 1719, 1728, 1734, 1738, 1744, 1747, 1751, 1754, 1759, 1763, 1767, 1772, 1779, 1784, 1791, 1796, 1800, 1804, 1810, 1812, 1815, 1826, 1832, 1836, 1837, 1850, 1854, 1860, 1864, 1868, 1872, 1875, 1881, 1883, 1888, 1892, 1902, 1906, 1910, 1915, 1920, 1931, 1941, 1954, 1967, 1981, 1991, 1998, 1998, 2010, 2014, 2024, 2028, 2033, 2039, 2044, 2049, 2054, 2062, 2064, 2070, 2078, 2083, 2085, 2092, 2096, 2101, 2109, 2114, 2123, 2126, 2136.

The surface hauls given in the following list did not contain Copepoda and therefore do not appear in table 3, which gives the numbers of individuals of the different species:

1432, 1436, 1438, 1444, 1448, 1452, 1455, 1460, 1465, 1478, 1488, 1499, 1504, 1509, 1512, 1532, 1559, 1562, 1686, 1689, 1695, 1712, 1716, 1747, 1751, 1759, 1763, 1767, 1796, 1800, 1804, 1810, 1812, 1815, 1832, 1854, 1868, 1910, 1915, 1941, 1967, 2039, 2044, 2049, 2078, 2085, 2114, 2242, 2313, 2316, 2351, 2361, 2446, 2491, 2511, 2523, 2526, 2539, 2542, 2545, 2557, 2564, 2571, 2573, 2588, 2594, 2607, 2620, 2751.

In table 3 is a list of the surface hauls and the number of specimens of each species occurring in the hauls. The numbers of specimens as given were obtained by actual count in most cases, though there are some entries of estimated numbers, especially when the numbers are large. It is but fair to state, however, that in some cases I counted the entire catch when the number was over a thousand; this is generally true for numbers less than a thousand. Estimated numbers may be relied upon as fairly exact.

TABLE 3

List of species and their numbers in the surface hauls named

Haul Number	*Calanus finmarchicus*	*Calanus gracilis*	*Calanus robustior*	*Candacia bipinnata*	*Candacia pectinata*	*Eucalanus elongatus*	*Euchaeta diegensis*	*Euchaeta media*	*Euchaeta spinosa*	*Euchirella pulchra*	*Euchirella rostrata*	*Gaidius pungens*	*Labidocera jollae*	*Labidocera trispinosa*	*Metridia lucens*	*Pleuromamma abdominalis*	*Pleuromamma gracilis*	*Pleuromamma quadrungulata*	*Pontellopsis occidentalis*	*Rhincalanus nasutus*	*Scolecithrix persecans*	*Undeuchaeta bispinosa*	*Undeuchaeta major*
1106	many	.....	.....	.....	.....	250	.....	.....	.....	.....	.....	.....	.....	many	.....	.....	.....	.....	.....	.....	.....	.....	.....
1119	.....	.....	.....	.....	.....	5	.....	.....	.....	.....	.....	.....	.....	500	.....	.....	.....	.....	.....	.....	.....	.....	.....
1125	5	.....	.....	.....	.....	300	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1137	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....
1158	7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1	.....	.....	.....	.....
1168	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1180	.....	.....	.....	.....	.....	22	.....	.....	.....	.....	1	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....
1190	50	.....	.....	.....	.....	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....
1210	.....	.....	.....	.....	.....	20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1224	200	.....	.....	.....	.....	200	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1309	.....	.....	.....	.....	.....	20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1321	5	.....	.....	.....	.....	250	.....	.....	.....	.....	.....	.....	1	.....	.....	1	.....	.....	.....	.....	.....	.....	.....
1345	.....	.....	.....	.....	.....	12	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1357	.....	.....	.....	.....	.....	15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1471	8	.....	.....	.....	.....	15	.....	.....	1	.....	.....	2	.....	.....	.....	.....	.....	2	.....	.....	1	.....	1
1530	.....	.....	.....	.....	.....	1	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1560	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1568	89	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....
1579	267	.....	.....	.....	.....	32	.....	.....	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	1	.....	.....	.....
1582	751	.....	.....	.....	.....	294	.....	.....	1	.....	1	.....	.....	2	224	1	.....	.....	.....	3	.....	.....	.....
1585	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Table 3—*Continued*

Haul Number	*Calanus finmarchicus*	*Calanus gracilis*	*Calanus robustior*	*Candacia bipinnata*	*Candacia pectinata*	*Eucalanus elongatus*	*Euchaeta diegensis*	*Euchaeta media*	*Euchaeta spinosa*	*Euchirella pulchra*	*Euchirella rostrata*	*Gaidius pungens*	*Labidocera jollae*	*Labidocera trispinosa*	*Metridia lucens*	*Pleuromamma abdominalis*	*Pleuromamma gracilis*	*Pleuromamma quadrungulata*	*Pontellopsis occidentalis*	*Rhincalanus nasutus*	*Scolecithrix persecans*	*Undeuchaeta bispinosa*	*Undeuchaeta major*
1588	29	.....	.....	.....	.....	22	.....	.....	.....	.....	.....	.....	.....	17	.....	.....	.....	.....	.....	.....	.....	.....	.....
1591	378	.....	.....	.....	.....	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1594	1500	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	.....
1597	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1600	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1605	13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1634	2300	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1650	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7	.....	.....	.....	.....	3	.....	.....	.....	.....
1653	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3	3	.....	.....	.....	.....	.....	.....	.....	.....	.....
1655	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1657	35	.....	.....	.....	.....	.....	.....	.....	.....	.....	4	.....	.....	2425	.....	.....	.....	.....	6	.....	.....	.....	.....
1667	1557	.....	.....	.....	.....	23	.....	.....	.....	.....	.....	.....	.....	232	.....	.....	.....	.....	.....	7	.....	.....	.....
1673	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1680	509	.....	.....	1	.....	59	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....
1682	1209	.....	.....	.....	.....	81	.....	.....	.....	.....	.....	.....	.....	198	.....	.....	.....	.....	.....	.....	.....	.....	.....
1698	.....	.....	.....	.....	.....	11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1703	7	.....	.....	.....	.....	43	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1719	76	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1728	20	.....	.....	.....	1	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1734	13	.....	.....	.....	.....	1	.....	.....	.....	.....	1	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....
1738	1790	.....	.....	1	.....	1	.....	.....	.....	1	1	.....	.....	.....	1	89	.....	.....	.....	1	.....	.....	.....
1744	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....

TABLE 3—*Continued*

Haul Number	*Calanus finmarchicus*	*Calanus gracilis*	*Calanus robustior*	*Candacia bipinnata*	*Candacia pectinata*	*Eucalanus elongatus*	*Euchaeta diegensis*	*Euchaeta media*	*Euchaeta spinosa*	*Euchirella pulchra*	*Euchirella rostrata*	*Gaidius pungens*	*Labidocera jollae*	*Labidocera trispinosa*	*Metridia lucens*	*Pleuromamma abdominalis*	*Pleuromamma gracilis*	*Pleuromamma quadrungulata*	*Pontellopsis occidentalis*	*Rhincalanus nasutus*	*Scolecithrix persecans*	*Undeuchaeta bispinosa*	*Undeuchaeta bispinosa*
1754	17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	.....	.....	.....	.....	.....	.....	.....	.....
1772	8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1779	22	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1784	546	.....	.....	.....	1	6	.....	.....	.....	.....	3	.....	.....	.....	.....	3	.....	.....	.....	.....	.....	.....	.....
1791	45	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1826	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1836	54	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1837	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1850	11	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	1	.....	.....	.....	.....	.....	.....	.....	.....
1864	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....
1872	80	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1875	3825	.....	.....	1	3	.....	.....	.....	.....	1	.....	.....	.....	.....	31900	14	15	.....	.....	.....	.....	2	.....
1881	29	.....	.....	2	.....	.....	.....	1	.....	1	.....	.....	.....	.....	3200	27	30	.....	.....	.....	.....	.....	.....
1883	367	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1820	.....	.....	.....	.....	.....	.....	1	.....
1888	58	.....	.....	3	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	476	1	.....	.....	.....	.....	.....	.....	.....
1892	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4	.....	.....	.....	.....	.....	.....	.....	.....
1902	75	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1906	7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1920	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	42	.....	.....	.....	.....	.....	.....	.....	.....
1931	.....	.....	.....	.....	.....	14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1954	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1981	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

TABLE 3—*Continued*

Haul Number	*Calanus finmarchicus*	*Calanus gracilis*	*Calanus robustior*	*Candacia bipinnata*	*Candacia pectinata*	*Eucalanus elongatus*	*Euchaeta diegenesis*	*Euchaeta media*	*Euchaeta spinosa*	*Euchirella pulchra*	*Euchirella rostrata*	*Gaidius pungens*	*Labidocera jollae*	*Labidocera trispinosa*	*Metridia lucens*	*Pleuromamma abdominalis*	*Pleuromamma gracilis*	*Pleuromamma quadrungulata*	*Pontellopsis occidentalis*	*Rhincalanus nasutus*	*Scolecithrix persecans*	*Undeuchaeta bispinosa*	*Undeuchaeta major*
1991	17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3	.....	.....	.....	.....	.....	.....	.....	.....	.....
1998	23	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....
2010	566	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2014	869	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2024	709	.....	.....	.....	.....	.....	.....	.....	.....	11	.....	.....	.....	2	.....	16	1	.....	.....	1	.....	.....	.....
2028	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2033	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2054	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2062	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	13	5	.....	.....	.....	.....	.....	.....	.....	.....	.....
2064	46	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2070	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2082	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6	.....	.....	1	.....	.....	2	.....	.....
2091	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2096	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2101	21	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....
2109	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	1	.....	.....	.....	.....	.....	.....	.....	.....
2123	93	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2126	34	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2136	191	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	1	.....	.....	.....	.....	.....	.....	.....	.....
2204	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2207	4	.....	.....	.....	.....	14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2213	100	.....	.....	.....	.....	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

TABLE 3—*Continued*

Haul Number	*Calanus finmarchicus*	*Calanus gracilis*	*Calanus robustior*	*Candacia bipinnata*	*Candacia pectinata*	*Eucalanus elongatus*	*Euchaeta diegensis*	*Euchaeta media*	*Euchaeta spinosa*	*Euchirella pulchra*	*Euchirella rostrata*	*Gaidius pungens*	*Labidocera jollae*	*Labidocera trispinosa*	*Metridia lucens*	*Pleuromamma abdominalis*	*Pleuromamma gracilis*	*Pleuromamma quadrungulata*	*Pontellopsis occidentalis*	*Rhincalanus nasutus*	*Scolecithrix persecans*	*Undeuchaeta bispinosa*	*Undeuchaeta major*
2219	18	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2224	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2228	79	.....	.....	1	1	23	.....	.....	.....	.....	.....	.....	.....	.....	.....	75	11	.....	.....	10	.....	2	.....
2259	3	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2264	18	1	.....	1	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	29	.....	.....	.....	2	.....	1	.....
2271	14	1	.....	5	.....	2	.....	.....	.....	2	.....	.....	.....	.....	.....	89	154	.....	.....	21	.....	19	.....
2295	5	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2328	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2331	87	.....	1	.....	2	6	.....	.....	.....	.....	.....	.....	.....	.....	182	6	1	.....	.....	.....	.....	.....	.....
2343	61	.....	.....	1	3	3	.....	.....	.....	.....	.....	.....	.....	.....	114	.....	.....	.....	.....	.....	.....	.....	.....
2346	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	.....	.....	.....	.....	.....	.....	.....
2376	608	.....	.....	7	1	44	.....	.....	.....	.....	.....	.....	.....	1	26	.....	.....	.....	.....	.....	.....	.....	.....
2391	18	.....	.....	1	.....	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2395	3	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2407	1	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2410	1	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2415	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2427	35	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19	6	.....	.....	.....	.....	.....	.....	.....
2431	8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	.....
2442	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	.....	.....	.....	.....	.....	.....	.....
2457	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Table 3—*Continued*

Haul Number	*Calanus finmarchicus*	*Calanus gracilis*	*Calanus robustior*	*Candacia bipinnata*	*Candacia pectinata*	*Eucalanus elongatus*	*Euchaeta diegensis*	*Euchaeta media*	*Euchaeta spinosa*	*Euchirella pulchra*	*Euchirella rostrata*	*Gaidius pungens*	*Labidocera jollae*	*Labidocera trispinosa*	*Metridia lucens*	*Pleuromamma abdominalis*	*Pleuromamma gracilis*	*Pleuromamma quadrungulata*	*Pontellopsis occidentalis*	*Rhincalanus nasutus*	*Scolecithrix persecans*	*Undeuchaeta bispinosa*	*Undeuchaeta major*
2473	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2476	90	.....	.....	6	2	57	.....	.....	.....	.....	1	.....	.....	.....	160	7	1	.....	.....	6	.....	.....	.....
2479	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	4	3	.....	.....	.....	.....	.....	.....	.....
2497	1	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....
2639	130	.....	.....	.....	.....	215	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....
2645	291	.....	.....	.....	.....	186	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2651	28	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2674	19	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....
2680	31	.....	.....	.....	.....	15	.....	.....	.....	.....	.....	.....	.....	41	.....	.....	.....	.....	.....	.....	.....	.....	.....
2679	9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2703	2	.....	.....	.....	.....	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2714	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2725	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2736	3	.....	.....	.....	.....	23	.....	.....	.....	.....	.....	.....	.....	6	.....	.....	.....	.....	.....	.....	.....	.....	.....
2747	4	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....
2749	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2753	2	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2755	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2756	15	.....	.....	.....	.....	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2760	20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2761	58	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....
2762	67	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

TABLE 5

List of species in the hauls made with the horizontal closing nets

Haul number	Depth in fathoms	*Aetideopsis decorata*	*Aetideopsis pacifica*	*Augaptilus pyramidalis*	*Calanus finmarchicus*	*Calanus gracilis*	*Candacia bipinnata*	*Candacia ethiopica*	*Candacia pachydactyla*	*Eucalanus elongatus*	*Euchaeta californica*	*Euchaeta media*	*Euchaeta tonsa*	*Euchirella curticauda*	*Euchirella galeata*	*Euchirella pulchra*	*Euchirella rostrata*	*Gaetanus brevicornis*	*Gaetanus secundus*	*Gaetanus unicornis*	*Gaidius pungens*	*Heterorhabdus longicornis*	*Heterorhabdus spinifrons*	*Metridia atra*	*Metridia lucens*	*Metridia princeps*	*Phyllopus integer*	*Pleuromamma abdominalis*	*Pleuromamma gracilis*	*Pleuromamma quadrungulata*	*Pleuromamma xiphias*	*Rhincalanus nasutus*	*Scolecithrix frontalis*	*Scolecithrix megna*	*Scolecithrix persecans*	*Undeuchaeta biepinosa*
1843	5				1																															
1873	5				12												1								5											
1879	5				271		1		1						1										219			3		1						2
1889	5				1																															
1792	6				186																															
1865	7 5				1																				45				1	3						
1855	10				1																															
1878	10				323																				284			39		2	1					
1789	12				42																															
1794	12				2																															
1834	15				80					5																										1
1845	15									1																										
1852	15				2					5																						1				
1877	15				55					5															3											
1885	15				1					1																										
1923	15																								1											
1668	20				215					3																										
1770	20				35																				14											
1785	20				15																															
1802	20				1																															
1748	25				13					13																										
1761	25				1																															
1788	25				3																															
1793	25				1					1																										
1817	25									2																										
1830	25				4																															
1851	25				5					3															3											
1870	25				33					2																										
1876	25				11							1				3									1			7			2				1	
1881	25				6																				2											
1930	25				1					19																										
1984	25									1																										
1844	30									3																										
1861	30				1					2															2											
1858	35									10																						1				
1603	50				12					155															3											
1620	50				1	10		1																												
1704	50				2					1																										
1708	50				1					2																										
1739	50				7					1											2				19											
1752	50				1					20															19										2	13
1760	50				3																				2											
1816	50									7																		1								
1846	50				1					11																										
1857	50									3																										
1866	50				25																															
1929	50				1					12																										
1966	50				2					2																		1								
1980	50									15											1										2					
1928	75				1					55																										
1688	100									1							1														1					
1691	100				7					2																										
1714	100				108					18																		1								
1753	100				1					4											2															
1757	100				23					11						2									50			2							2	
1813	100				48		1			44							1								10			7							4	
1824	100				2					1															1											
1869	100				11					3															15											
1947	100									1																										
1965	100				1					17						11					49							16				1		3	
1979	100									6																				1					
1736	110				8					6																										
1927	125				8					116																										
1684	150				5																				2											
1701	150				13					2															5			1		2				1	
1756	150				10					1											2															
1764	150				7					1						1					6				23					6		1				
1735	160				41					2			1												2					4						
1576	200				6					5				1							6									7	1				3	
1690	200				37					1											2				3					1		1				1
1700	200				46					1											6	1	2		1					1						1
1745	200				3																															
1926	200				11					53																										
1948	200									14																										
1964	200		1		8					16			1		1	1									3		1			2		1	4		2	7
1978	200				5					49				1		9					63							13		15	2					
1732	220				15					3										2																
1557	250			1	1					250	1		2	4	2	3	1			1	4							21		4	4			1	1	3
1683	250				3																									2						
1699	250				12																		2				1									
1729	250				19					1																		1					1			
1578	300				1					1															1					1					2	
1726	300				20																	1				1										
1963	300				5					6															2					3					1	1
1550	350				1					7			7		1	1		1	1	3							1			2	1	1	2	1		1
1567	350	1			6					42											5					1	1	1					4	1		4
1977	400				2					5						1																				
1976	550				1																			1												

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The following list contains the numbers of the hauls made with the horizontal closing nets that I used.

1542, 1550, 1557, 1567, 1572, 1575, 1576, 1578, 1603, 1620, 1621, 1668, 1683, 1684, 1688, 1690, 1691, 1699, 1700, 1701, 1704, 1708, 1714, 1725, 1726, 1729, 1732, 1735, 1736, 1739, 1745, 1748, 1752, 1753, 1756, 1757, 1760, 1761, 1764, 1770, 1785, 1788, 1789, 1792, 1793, 1794, 1797, 1798, 1801, 1802, 1805, 1807, 1808, 1813, 1816, 1817, 1820, 1821, 1824, 1827, 1828, 1830, 1833, 1834, 1839, 1840, 1841, 1842, 1843, 1844, 1845, 1846, 1851, 1852, 1855, 1856, 1857, 1858, 1861, 1862, 1865, 1866, 1869, 1870, 1873, 1876, 1877, 1878, 1879, 1884, 1885, 1886, 1889, 1909, 1923, 1926, 1927, 1928, 1929, 1930, 1944, 1946, 1947, 1948, 1963, 1964, 1965, 1966, 1976, 1977, 1978, 1979, 1980, 1984.

The data for the above hauls are given in table 30 of Michael's paper except for the two hauls in table 4 which follows.

TABLE 4

Data for hauls with horizontal closing nets not given in table 30 of Michael's paper

Haul number	Date 1909	Time of day	Duration minutes	Net	Depth in fathoms	North Latitude	West Longitude
1976	Nov. 5	9:45–10:00 a.m.	15	B	550	32° 40′6	117° 30′3
1977	Nov. 5	10:45–11:00 a.m.	15	B	400	32° 40′6	117° 30′3

In table 5 which follows, is given a list of the species occurring in all of the above collections. The hauls are arranged according to depths. The following hauls of the list given above did not contain Copepoda:

1542, 1572, 1575, 1621, 1725, 1797, 1798, 1801, 1805, 1807, 1808, 1820, 1821, 1827, 1828, 1833, 1839, 1840, 1841, 1842, 1856, 1862, 1886, 1909, 1944, 1946.

These do not appear in table 5.

I made use, in part, of the following hauls with the vertical closing nets; the data for the hauls will be found in tables 30 and 31 of Michael's paper:

1994, 1995, 1996, 1997, 2001, 2017, 2018, 2027, 2031, 2032, 2036, 2037, 2038, 2048, 2052, 2053, 2057, 2058, 2059, 2067, 2068, 2069, 2073, 2074, 2075, 2081, 2088, 2089, 2090, 2094, 2095, 2099, 2106, 2107, 2108, 2112, 2113, 2119, 2120, 2121, 2122, 2131, 2132, 2133, 2134, 2135, 2139, 2140, 2141, 2142, 2143, 2144.

These hauls all contained copepods except numbers 2027, 2037, 2140, 2141, and 2088, and in table 6, which follows, there are lists of species as they occurred in the hauls given above; in the table the hauls are arranged according to depths, the hauls in shallower water being put first. All of the foregoing collections were made before June, 1911.

The other hauls with the vertical closing nets form a group by themselves in that they were made in June and August, 1911, above 75 fathoms, and nearly everyone on some one of three stations located as follows:

	North Latitude	West Longitude
Station 1	32° 23′.5	117° 18′.0
Station 2	32° 22′.7	117° 19′.2
Station 3	32° 22′.4	117° 21′.2

A few hauls were made at a station in Ritter Deep, 32°40′ north latitude, 117°32′ west longitude; a few at a station off San Clemente Island in 32°50′ north latitude and 118°20′.3 west longitude; a station near La Jolla was covered a few times, 32°50′ north latitude and 117°30′ west longitude. In table 7 following, the six positions named above are referred to as Stations 1, 2, or 3 (as the case may be), Ritter Deep, Clemente and La Jolla. The list of hauls in table 7 is arranged according to depths as shown. It is not necessary to give duration of hauls, since the nets are drawn at the rate of two feet per second in every case.

TABLE 6

List of species and numbers of individuals in the vertical closing hauls made before June, 1911 (see list on page 267)

Haul number	Depth in fathoms	*Aetideopsis pacifica*	*Calanus finmarchicus*	*Eucalanus elongatus*	*Euchaeta diegensis*	*Euchaeta media*	*Euchaeta spinifer*	*Euchaeta spinosa*	*Euchaeta tonsa*	*Euchirella curticauda*	*Euchirella galeata*	*Euchirella pulchra*	*Gaetanus secundus*	*Gaetanus unicornis*	*Gaidius pungens*	*Heterorhabdus longicornis*	*Heterorhabdus spinifrons*	*Metridia lucens*	*Metridia princeps*	*Phyllopus integer*	*Pleuromamma abdominalis*	*Pleuromamma gracilis*	*Pleuromamma quadrungulata*	*Pleuromamma xiphias*	*Rhincalanus nasutus*	*Scolecithrix frontalis*	*Scolecithrix magna*	*Scolecithrix persecans*	*Undeuchaeta bispinosa*	*Undeuchaeta incisa*	*Xanthocalanus similis*	*Xanthocalanus tectus*
1994	75–50	....	4	.....	....	....	....	....	....	....	....	....	....	....	.....	....	....	.....	....	....	....	.....	....	....	....	....	....	.....	....	....	....	....
2038	75–50	....	13	.....	....	....	....	....	....	....	....	....	....	....	.....	....	....	.....	....	....	....	.....	....	....	....	....	....	.....	....	....	....	....
2059	75–50	....	20	.....	....	....	....	....	....	....	....	....	....	....	.....	....	....	40	....	....	....	.....	....	....	1	....	....	.....	....	....	....	....
2075	75–50	....	294	.....	....	....	....	....	....	....	....	....	....	....	.....	....	....	426	....	....	....	.....	....	....	....	....	....	.....	....	....	....	....
2099	75–50	....	71	1	....	....	....	....	....	....	....	1	....	....	.....	....	....	165	....	....	....	.....	....	....	2	10	....	14	3	....	....	1
2106	75–50	....	11	.....	....	....	....	....	....	....	....	....	....	....	.....	....	....	2	....	....	....	.....	....	....	....	....	....	.....	....	....	....	....
2119	75–50	....	2	.....	....	....	....	....	....	....	....	....	....	....	1	....	....	.....	....	....	....	.....	....	....	1	....	....	3	....	....	....	....
2131	75–50	....	1	1	....	....	....	....	....	....	....	....	....	....	2	....	....	.....	....	....	2	.....	....	1	....	2	....	1	....	....	....	....
2142	75–50	....	.....	4	....	....	....	....	....	....	....	....	....	....	.....	....	....	.....	....	....	....	.....	....	....	....	....	....	.....	....	....	....	....
1995	100–75	....	.....	4	....	....	....	....	....	....	....	....	....	....	.....	....	....	5	....	....	....	.....	....	....	....	....	....	.....	....	....	....	....
2058	100–75	....	45	.....	....	....	....	....	....	....	....	....	....	....	.....	....	....	.....	....	....	....	.....	....	....	....	....	....	.....	....	....	....	....
2074	100–75	....	89	1	....	....	....	....	....	....	....	....	....	....	.....	....	....	192	....	....	....	.....	....	....	5	....	....	.....	....	....	....	....
2095	100–75	....	239	4	....	....	....	....	....	....	....	12	....	....	.....	....	....	1036	....	....	1	.....	....	....	4	....	....	28	....	....	....	....
2107	100–75	....	9	1	....	....	....	....	....	....	....	....	....	....	.....	....	....	.....	....	....	....	.....	....	....	....	....	....	.....	....	....	....	....
2120	100–75	....	1	.....	....	....	....	....	....	....	1	....	....	....	.....	....	....	.....	....	....	....	.....	....	....	....	....	....	7	....	....	....	....
2132	100–75	....	.....	.....	....	....	....	....	....	....	....	....	....	....	.....	....	....	.....	....	....	....	.....	....	....	1	....	....	.....	....	....	....	....
2143	100–75	....	.....	4	....	....	....	....	....	....	....	....	....	....	.....	....	....	.....	....	....	....	.....	....	....	2	....	....	.....	....	....	....	....
1996	150–100	....	2	23	....	....	....	....	....	....	....	....	....	....	.....	....	....	137	....	....	2	.....	....	....	4	....	....	2	....	....	....	....
2018	150–100	....	65	33	....	....	....	....	....	....	....	....	....	....	11	....	1	107	....	....	1	.....	3	....	1	....	....	10	2	....	....	....
2036	150–100	....	4	.....	....	....	....	....	....	....	....	....	....	....	.....	....	....	.....	....	....	....	.....	....	....	....	....	....	2	....	....	....	....
2057	150–100	....	183	1	4	....	....	....	....	....	....	....	....	....	.....	....	....	31	....	....	....	.....	....	....	1	....	....	.....	....	....	....	....
2073	150–100	....	27	12	....	....	....	....	....	....	....	....	....	....	.....	....	....	56	....	....	....	10	....	....	6	....	....	25	....	....	....	....
2094	150–100	....	47	37	....	....	....	....	....	....	3	8	....	....	18	....	....	391	....	....	4	.....	....	....	8	2	....	17	....	....	....	....
2108	150–100	....	9	8	....	....	....	....	....	....	....	....	....	....	.....	....	....	27	....	....	....	.....	....	....	5	....	....	.....	....	....	....	....
2121	150–100	....	1	.....	....	....	....	....	....	....	....	....	....	....	.....	....	....	2	....	....	....	.....	....	....	1	....	....	5	....	....	....	....
2133	150–100	....	1	9	....	....	....	....	....	....	....	....	....	....	3	....	....	.....	....	....	....	.....	5	....	2	1	1	.....	....	....	....	....
2144	150–100	....	18	.....	....	....	....	....	....	....	....	....	....	....	.....	....	....	.....	....	....	....	.....	....	....	....	....	....	.....	....	....	....	....
1997	200–150	....	68	51	....	....	....	....	....	....	....	....	....	....	.....	....	....	568	....	....	12	32	1	....	6	....	....	16	....	....	....	....
2017	200–150	1	33	19	....	....	....	....	....	....	....	....	....	....	19	....	....	32	....	....	1	.....	5	....	1	....	....	2	....	....	....	....
2032	200–150	....	43	90	....	1	....	....	....	....	....	2	....	....	32	....	....	109	....	....	10	.....	16	....	20	....	....	67	....	....	....	....
2053	200–150	....	12	45	....	....	....	....	....	....	....	....	....	1	2	....	....	9	....	....	1	253	3	....	3	....	....	4	....	....	....	....
2069	200–150	....	58	155	....	....	....	1	....	....	....	5	1	....	5	....	....	472	....	....	2	8	2	....	2	....	....	51	....	....	....	....
2090	200–150	....	57	20	....	....	....	....	....	....	1	5	....	....	11	....	....	57	....	1	3	.....	5	....	1	1	....	15	1	....	....	....
2112	200–150	....	4	33	....	....	....	....	....	....	....	2	....	....	7	....	1	252	....	....	7	.....	....	....	3	....	....	2	....	....	....	....
2122	200–150	....	.....	15	....	....	....	....	....	....	....	....	....	....	2	....	....	.....	....	....	1	.....	1	....	....	....	....	3	....	....	....	....
2134	200–150	....	1	39	....	....	....	....	....	....	....	....	....	....	5	....	....	1	....	....	....	.....	4	1	2	3	1	.....	....	....	....	....
2001	250–200	5	7	12	....	....	....	....	....	....	3	3	....	....	68	1	....	58	....	....	2	2	15	4	....	....	....	10	....	....	....	....
2031	250–200	....	28	19	....	....	....	....	3	....	1	8	....	4	114	....	1	63	....	....	4	.....	40	....	10	....	....	64	31	....	....	....
2052	250–200	....	29	82	....	....	....	....	....	....	....	23	....	2	97	....	....	87	....	....	6	.....	47	1	1	7	3	10	10	1	1	1
2068	250–200	....	133	380	....	2	....	....	....	....	....	8	....	....	11	....	1	542	....	....	14	.....	32	11	11	1	....	105	....	....	....	....
2089	250–200	....	19	30	....	....	3	....	2	....	4	2	....	....	17	....	....	51	....	....	2	.....	12	....	2	10	....	14	3	....	....	....
2113	250–200	1	4	21	....	....	....	....	....	....	....	3	....	....	9	....	1	22	....	....	1	.....	8	....	2	....	....	.....	....	....	....	....
2135	250–200	....	.....	1	....	....	....	....	....	....	....	....	....	....	.....	....	....	.....	....	....	....	.....	1	....	....	....	....	.....	....	....	....	....
2048	300–250	1	31	61	....	....	....	2	1	....	4	17	....	1	96	....	....	69	1	10	17	.....	17	1	6	....	1	9	16	....	....	....
2067	300–250	....	.....	178	....	1	....	....	4	1	7	4	....	5	230	1	....	378	....	....	8	.....	51	6	8	4	....	54	10	....	....	1
2081	300–250	....	27	47	....	....	....	....	6	....	1	3	....	....	19	....	....	42	....	1	3	.....	7	....	3	2	3	11	3	....	....	....
2139	300–250	....	1	1	....	....	....	....	....	....	....	....	....	....	.....	....	....	.....	....	....	....	.....	1	....	....	....	....	.....	....	....	....	....

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TABLE 7

Hauls made with the vertical closing net in June and August, 1911 (Net E), with numbers of specimens of the more abundant species

Haul number	Date 1911	Time of day	Station	*Calanus finmarchicus*	*Eucalanus elongatus*	*Labidocera trispinosa*	*Metridia lucens*	*Pleuromamma abdominalis*	*Pleuromamma xiphias*	*Rhincalanus nasutus*
	A. Hauls 5-0 fathoms									
2303	June 14	6:35 a.m.	3	1	....	....	....	....	....	....
2342	June 15	11:58 a.m.	2	....	....	....	2	....	....	....
2390	June 16	3:20 p.m.	1	7	1	....	....	....	....	....
2650	Aug. 8	5:30 a.m.	1	15	3	....	....	....	....	....
2673	Aug. 8	8:24 a.m.	1	12	....	....	....	....	....	....
2691	Aug. 9	4:20 a.m.	2	1	1	7	....	....	....	....
2702	Aug. 9	5:36 a.m.	2	1	1	1	....	....	....	....
2713	Aug. 9	8:08 a.m.	2	....	....	3	....	....	....	....
2724	Aug. 9	9:17 a.m.	3	5	....	3	....	....	....	....
2735	Aug. 9	4:47 a.m.	3	1	....	....	....	....	....	....
2746	Aug. 9	5:52 a.m.	3	2	....	....	....	....	....	....
	B. Hauls 10-5 fathoms									
2341	June 14	3:10 a.m.	2	....	1	....	4	....	....	....
2389	June 16	3:16 a.m.	1	27	1	....	....	....	....	....
2440	June 17	3:15 a.m.	3	1	1	....	....	....	....	....
2489	June 18	3:30 a.m.	2	....	1	....	....	....	....	....
2605	June 24	4:27 p.m.	Clemente	3	....	....	....	....	....	....
2618	June 26	5:02 a.m.	2	....	1	....	....	....	....	....
2649	Aug. 8	5:23 a.m.	1	3	2	....	....	....	....	....
2660	Aug. 8	8:21 a.m.	1	18	....	....	....	....	....	....
2672	Aug. 8	8:21 a.m.	1	3	1	....	....	....	....	....
2690	Aug. 9	4:16 a.m.	2	5	....	1	....	....	....	....
2701	Aug. 9	5:33 a.m.	2	....	1	....	....	....	....	....
2712	Aug. 9	8:05 a.m.	2	5	4	....	....	....	....	....
2722	Aug. 9	9:15 a.m.	3	3	....	....	....	....	....	....
2734	Aug. 9	4:43 a.m.	3	....	6	....	....	....	....	....
2745	Aug. 9	5:53 a.m.	3	13	3	1	....	....	....	....
	C. Hauls 15-10 fathoms									
2302	June 14	6:30 a.m.	3	....	1	....	....	....	....	....
2310	June 14	7:40 a.m.	3	....	1	....	....	....	....	....
2340	June 15	3:07 a.m.	2	5	2	....	7	....	....	....
2373	June 15	8:54 a.m.	2	....	1	....	....	....	....	....
2388	June 16	3:11 a.m.	1	76	3	....	14	....	....	....

Table 7—*Continued*

Haul number	Date 1911	Time of day	Station	*Calanus finmarchicus*	*Eucalanus elongatus*	*Labidocera trispinosa*	*Metridia lucens*	*Pleuromamma abdominalis*	*Pleuromamma xiphias*	*Rhincalanus nasutus*
2404	June 16	5:30 a.m.	1	....	1	....	....	....	....	....
2424	June 16	9:15 a.m.	1	....	1	....	....	....	....	....
2439	June 17	3:11 a.m.	3	4	3	....	1	....	....	....
2488	June 18	3:25 a.m.	2	....	2	....	....	....	....	....
2604	June 24	5:25 p.m.	Clemente	24	....	....	....	....	....	....
2648	Aug. 8	5:10 a.m.	1	3	3	....	....	....	....	....
2659	Aug. 8	6:44 a.m.	1	3	....	....	....	....	....	....
2671	Aug. 8	8:15 a.m.	1	10	2	....	....	....	....	....
2700	Aug. 9	5:30 a.m.	2	1	1	....	....	....	....	....
2711	Aug. 9	8:00 a.m.	2	3	....	....	....	....	....	....
2722	Aug. 9	9:12 a.m.	3	2	....	....	....	....	....	....
2733	Aug. 9	4:37 a.m.	3	1	2	....	....	....	....	....
2744	Aug. 9	5:48 a.m.	3	9	1	....	....	....	....	....
	D. Hauls 10-15 fathoms									
2301	June 14	6:27 a.m.	3	....	1	....	....	....	....	....
2309	June 14	7:32 a.m.	3	....	8	....	....	....	....	....
2339	June 15	3:02 p.m.	2	10	1	....	33	....	....	1
2357	June 15	5:35 a.m.	2	....	2	....	....	....	....	....
2387	June 16	3:08 a.m.	1	33	5	....	12	....	....	2
2403	June 16	5:20 a.m.	1	3	....	....	....	....	....	....
2423	June 16	9:07 a.m.	1	....	3	....	....	....	....	....
2438	June 17	3:07 a.m.	3	8	6	....	....	....	....	1
2453	June 17	5:42 a.m.	3	....	1	....	....	....	....	....
2487	June 18	3:22 a.m.	2	2	2	....	....	....	....	....
2506	June 18	5:17 a.m.	2	....	1	....	....	....	....	....
2534	June 20	5:52 a.m.	1	....	....	....	1	....	....	....
2603	June 24	4:20 p.m.	Clemente	15	1	....	....	....	....	....
2644	Aug. 8	4:55 a.m.	1	2	9	....	....	....	....	....
2658	Aug. 8	6:40 a.m.	1	....	4	....	....	....	....	....
2669	Aug. 8	7:15 a.m.	1	1	....	....	....	....	....	....
2688	Aug. 9	4:06 a.m.	2	2	2	....	4	....	....	....
2699	Aug. 9	5:25 a.m.	2	....	1	....	....	....	....	....
2710	Aug. 9	7:51 a.m.	2	1	....	....	....	....	....	....
2721	Aug. 9	9:00 a.m.	3	4	....	....	....	....	....	....
2732	Aug. 9	4:33 a.m.	3	6	....	....	....	....	....	....
2743	Aug. 9	5:45 a.m.	3	12	1	....	....	....	....	....

TABLE 7—*Continued*

Haul number	Date 1911	Time of day	Station	*Calanus finmarchicus*	*Eucalanus elongatus*	*Labidocera trispinosa*	*Metridia lucens*	*Pleuromamma abdominalis*	*Pleuromamma xiphias*	*Rhincalanus nasutus*
	E. Hauls 25-20 fathoms									
2300	June 14	6:20 a.m.	3	1	3	....	....	....	....	....
2308	June 14	7:25 a.m.	3	....	10	....	....	....	....	....
2323	June 14	11:40 a.m.	3	....	2	....	....	....	....	....
2338	June 15	2:58 a.m.	2	1	1	....	2	....	....	....
2356	June 15	5:30 a.m.	2	13	6	....	53	....	....	....
2371	June 15	8:45 a.m.	2	....	2	....	....	....	....	....
2386	June 16	3:04 a.m.	1	21	5	....	9	....	....	....
2402	June 16	5:15 a.m.	1	....	3	....	....	....	....	....
2422	June 16	9:05 a.m.	1	....	6	....	....	....	....	....
2437	June 17	3:00 a.m.	3	15	13	....	12	1	....	....
2452	June 17	5:38 a.m.	3	....	4	....	....	....	....	....
2467	June 17	8:10 a.m.	3	....	1	....	....	....	....	....
2518	June 18	6:55 a.m.	Clemente	....	3	....	....	....	....	....
2602	June 24	4:15 a.m.	2	1	....	....	....	....	....	....
2615	June 26	4:47 a.m.	1	1	3	....	....	....	....	....
2657	Aug. 8	6:35 a.m.	1	2	2	....	....	....	....	....
2668	Aug. 8	7:48 a.m.	1	3	1	....	....	....	....	....
2687	Aug. 9	4:00 a.m.	2	1	1	....	5	....	....	....
2698	Aug. 9	5:20 a.m.	2	1	4	....	....	....	....	....
2709	Aug. 9	7:53 a.m.	2	....	....	1	....	....	....	....
2720	Aug. 9	9:03 a.m.	3	3	2	....	....	....	....	....
2731	Aug. 9	4:27 a.m.	3	5	2	....	....	....	....	....
2742	Aug. 9	5:38 a.m.	3	14	2	1	....	....	....	....
	F. Hauls 30-25 fathoms									
2299	June 14	6:12 a.m.	3	....	19	....	....	....	....	....
2307	June 14	7:15 a.m.	3	....	....	....	....	....	....	1
2322	June 14	11:34 a.m.	3	....	2	....	....	....	....	....
2337	June 15	2:54 a.m.	2	12	2	....	43	....	....	....
2355	June 15	5:26 a.m.	2	....	7	....	....	....	....	....
2371	June 15	8:40 a.m.	2	....	2	....	....	....	....	....
2385	June 16	2:59 a.m.	1	31	5	....	58	....	1	....
2401	June 16	5:10 a.m.	1	....	2	....	....	....	....	....
2421	June 16	8:55 a.m.	1	....	6	....	....	....	....	....
2436	June 17	2:55 a.m.	3	8	2	....	12	....	1	1
2451	June 17	5:35 a.m.	3	....	1	....	....	....	....	....

Table 7—*Continued*

Haul number	Date 1911	Time of day	Station	*Calanus finmarchicus*	*Eucalanus elongatus*	*Labidocera trispinosa*	*Metridia lucens*	*Pleuromamma abdominalis*	*Pleuromamma xiphias*	*Rhincalanus nasutus*
2466	June 17	8:04 a.m.	3	....	2	....	....	....	....	....
2485	June 18	3:15 a.m.	2	5	....	....	13	....	....	....
2503	June 18	5:05 a.m.	2	....	1	....	....	....	....	....
2517	June 18	6:50 a.m.	2	....	4	....	....	....	....	....
2551	June 20	8:35 a.m.	1	1	1	....	....	....	....	....
2562	June 20	10:35 a.m.	1	11	....	....	....	....	....	....
2601	June 24	4:12 p.m.	Clemente	7	1	....	....	....	....	....
2614	June 26	4:40 a.m.	2	2	2	....	....	....	....	....
2642	Aug. 8	4:15 a.m.	1	15	4	....	3	....	....	....
2656	Aug. 8	6:28 a.m.	1	7	....	....	....	....	....	....
2667	Aug. 8	7:37 a.m.	1	2	3	....	....	....	....	....
2686	Aug. 9	3:55 a.m.	2	2	....	....	5	....	....	....
2697	Aug. 9	5:14 a.m.	2	3	1	....	....	....	....	....
2708	Aug. 9	7:45 a.m.	2	1	5	....	....	....	....	....
2719	Aug. 9	8:57 a.m.	3	1	1	....	....	....	....	....
2730	Aug. 9	4:20 a.m.	3	9	1	....	....	1	....	....
2741	Aug. 9	5:32 a.m.	3	11	2	....	....	....	....	....
	G. Hauls 40-30 fathoms									
2298	June 14	5:50 a.m.	3	1	1	....	1	....	....	....
2306	June 14	7:07 a.m.	3	....	5	....	....	....	....	....
2321	June 14	11:27 a.m.	3	....	7	....	....	....	....	....
2336	June 15	2:43 a.m.	2	13	6	....	53	....	....	....
2354	June 15	5:20 a.m.	2	1	4	....	....	....	....	....
2369	June 15	8:27 a.m.	2	....	1	....	....	....	....	....
2384	June 16	2:52 a.m.	1	10	3	....	30	....	....	....
2400	June 16	5:05 a.m.	1	2	7	....	....	....	....	....
2420	June 16	8:52 a.m.	1	1	4	....	....	....	....	....
2435	June 17	2:47 a.m.	3	1	1	....	9	1	....	....
2450	June 17	5:30 a.m.	3	....	3	....	....	....	....	....
2484	June 18	3:10 a.m.	2	1	2	....	9	1	....	....
2502	June 18	5:00 a.m.	2	....	2	....	....	....	....	....
2516	June 18	6:45 a.m.	2	....	8	....	....	....	....	....
2531	June 20	5:37 a.m.	1	5	7	....	....	....	....	....
2550	June 20	8:25 a.m.	1	2	2	....	....	....	....	....
2561	June 20	10:30 a.m.	1	19	4	....	....	....	....	....

TABLE 7—*Continued*

Haul number	Date 1911	Time of day	Station	*Calanus finmarchicus*	*Eucalanus elongatus*	*Labidocera trispinosa*	*Metridia lucens*	*Pleuromamma abdominalis*	*Pleuromamma xiphias*	*Rhincalanus nasutus*
2580	June 22	6:30 a.m.	Ritter Deep	....	1	....	....	....	....	....
2599	June 24	4:04 p.m.	Clemente	3	4	....	....	....	....	....
2612	June 26	4:25 a.m.	2	2	5	....	....	....	....	....
2638	Aug. 8	4:03 a.m.	1	5	....	....	....	....	....	....
2655	Aug. 8	6:22 a.m.	1	11	1	....	....	....	....	....
2666	Aug. 8	7:35 a.m.	1	2	....	....	....	....	....	....
2685	Aug. 9	3:47 a.m.	2	3	....	....	8	....	....	....
2707	Aug. 9	7:40 a.m.	2	2	4	....	....	....	....	....
2718	Aug. 9	8:53 a.m.	3	....	4	....	....	....	....	....
2740	Aug. 9	5:25 a.m.	3	8	2	1	....	....	....	....
	H. Hauls 50-40 fathoms									
2294	June 14	5:35 a.m.	3	2	13	....	....	....	....	....
2305	June 14	7:00 a.m.	3	....	4	....	....	....	....	....
2320	June 14	11:20 a.m.	3	1	7	....	....	....	....	....
2335	June 15	2:35 a.m.	2	12	2	....	48	....	....	....
2350	June 15	5:10 a.m.	2	1	1	....	....	1	....	....
2368	June 15	8:22 a.m.	2	....	7	....	....	....	....	1
2383	June 16	2:45 a.m.	1	16	1	....	26	....	....	....
2399	June 16	5:00 a.m.	1	4	3	....	1	....	....	....
2419	June 16	8:45 a.m.	1	....	1	....	....	....	....	....
2434	June 17	2:40 a.m.	3	1	....	....	11	....	....	....
2449	June 17	5:12 a.m.	3	....	13	....	....	....	....	....
2464	June 17	7:50 a.m.	3	....	10	....	....	....	....	1
2483	June 18	3.02 a.m.	2	4	1	....	7	1	....	....
2501	June 18	4:50 a.m.	2	....	9	....	....	....	....	1
2515	June 18	6:38 a.m.	2	1	4	....	1	....	....	....
2530	June 20	5:30 a.m.	1	26	6	....	....	....	....	....
2549	June 20	8:15 a.m.	1	9	....	....	....	....	....	1
2560	June 20	10:20 a.m.	1	13	2	....	1	....	....	1
2593	June 22	1:00 a.m.	La Jolla	....	8	....	....	....	....	....
2598	June 24	3:56 p.m.	Clemente	21	4	....	....	....	....	....
2611	June 26	4:16 a.m.	2	10	1	....	....	....	....	....
2627	June 26	7:55 a.m.	3	....	3	....	....	....	....	....
2637	Aug. 8	3:50 a.m.	1	8	2	....	6	....	....	....
2654	Aug. 8	6:10 a.m.	1	2	1	....	....	....	....	....

Table 7—*Continued*

Haul number	Date 1911	Time of day	Station	*Calanus finmarchicus*	*Eucalanus elongatus*	*Labidocera trispinosa*	*Metridia lucens*	*Pleuromamma abdominalis*	*Pleuromamma xiphias*	*Rhincalanus nasutus*
2665	Aug. 8	7:27 a.m.	1	1	1	....	....	....	....	....
2684	Aug. 8	3:38 a.m.	1	3	....	1	....	....	....	....
2695	Aug. 9	5:04 a.m.	2	1	2	....	2	....	....	....
2739	Aug. 9	5:15 a.m.	3	6	1	1	....	....	....	....
	I. Hauls 75-50 fathoms									
2293	June 14	5:20 a.m.	3	19	13	....	....	....	....	....
2304	June 14	6:50 a.m.	3	....	10	....	....	....	....	....
2319	June 14	11:05 a.m.	3	....	16	....	....	....	....	....
2334	June 15	2:23 a.m.	2	8	7	....	42	....	1	....
2349	June 15	5:03 a.m.	2	13	8	....	1	....	....	....
2364	June 16	8:10 a.m.	1	....	15	....	2	....	....	....
2379	June 16	2:35 a.m.	1	27	....	....	20	....	....	....
2394	June 16	4:45 a.m.	1	45	....	....	5	....	....	....
2418	June 17	8:40 a.m.	3	1	1	....	2	....	....	....
2430	June 17	2:30 a.m.	3	2	1	....	4	....	....	....
2444	June 17	5:04 a.m.	2	1	....	....	....	....	....	....
2460	June 17	7:42 a.m.	2	....	5	....	....	....	....	....
2482	June 17	2:55 a.m.	2	4	1	....	8	....	....	....
2500	June 17	4:40 a.m.	2	4	5	....	6	....	....	2
2514	June 20	6:30 a.m.	1	1	7	....	7	....	....	....
2529	June 20	5:20 a.m.	1	184	4	....	7	....	....	1
2548	June 22	8:05 a.m.	Ritter Deep	41	4	....	9	....	....	....
2576	June 22	6:00 a.m.	La Jolla	2	3	....	....	....	....	....
2591	June 24	9:45 a.m.	Clemente	....	3	....	....	....	....	....
2597	June 26	3:47 p.m.	2	....	10	....	....	....	....	1
2610	June 26	4:01 a.m.	3	28	1	....	19	....	....	....
2626	June 26	7:40 a.m.	3	....	10	....	....	....	....	....
2694	Aug. 9	4:50 a.m.	2	1	2	....	8	....	....	1
2738	Aug. 9	5:10 a.m.	3	5	....	1	....	....	....	....

The list of species given in the above table comprises the more important ones, but the following should be added:

Haul number	Depth	Species	
2436	30–25	*Gaidius pungens*	1
2436	30–25	*Undeuchaeta bispinosa*	1
2686	30–25	*Euchirella curticauda*	1
2686	30–25	*Undeuchaeta bispinosa*	1
2384	40–30	*Euchirella rostrata*	1
2685	40–30	*Euchirella curticauda*	1
2368	50–40	*Euchirella rostrata*	1
2434	50–40	*Euchirella galeata*	1
2434	50–40	*Undeuchaeta bispinosa*	2
2501	50–40	*Euchirella rostrata*	2
2637	50–40	*Undeuchaeta bispinosa*	1
2684	50–40	*Pleuromamma gracilis*	1
2684	50–40	*Euchirella pulchra*	1
2684	50–40	*Undeuchaeta bispinosa*	1
2334	75–50	*Gaidius pungens*	1
2334	75–50	*Undeuchaeta bispinosa*	1
2430	75–50	*Gaidius pungens*	6
2430	75–50	*Scolecithrix frontalis*	1
2482	75–50	*Scolecithrix frontalis*	2
2576	75–50	*Gaidius pungens*	1

The following hauls (table 8) in the same group as those given in table 7 did not contain Copepoda.

TABLE 8

Data for hauls with vertical closing nets made in June and August, 1911, and containing no Copepoda. Net E.

A. Hauls 5-0 fathoms

Haul number	Date 1911	Time of day	Position
2312	June 14	7:50 a.m.	Station 3
2327	June 14	11:58 a.m.	Station 3
2360	June 15	5:45 a.m.	Station 2
2375	June 15	9:01 a.m.	Station 2
2406	June 16	5:35 a.m.	Station 1
2426	June 16	9:18 a.m.	Station 1
2441	June 17	3:20 a.m.	Station 3
2456	June 17	5:32 a.m.	Station 3

Haul number	Date 1911	Time of day	Position
2472	June 17	8:25 a.m.	Station 3
2490	June 18	3:32 a.m.	Station 2
2510	June 18	5:25 a.m.	Station 2
2522	June 18	7:10 a.m.	Station 2
2537	June 18	6:00 a.m.	Station 1
2556	June 18	8:55 a.m.	Station 1
2587	June 22	6:59 a.m.	Ritter Deep
2606	June 24	4.37 p.m.	Clemente
2619	June 26	5:07 a.m.	Station 2
2634	June 26	8:35 a.m.	Station 3

B. Hauls 10-5 fathoms

2311	June 14	7:46 a.m.	Station 3
2326	June 14	11:54 a.m.	Station 3
2359	June 15	5:42 a.m.	Station 2
2374	June 15	8:58 a.m.	Station 2
2405	June 16	5:33 a.m.	Station 1
2425	June 16	9:17 a.m.	Station 1
2455	June 17	5:49 a.m.	Station 3
2471	June 17	8:22 a.m.	Station 3
2508	June 18	5:23 a.m.	Station 2
2521	June 18	7:08 a.m.	Station 2
2536	June 20	5:58 a.m.	Station 1
2555	June 20	8:52 a.m.	Station 1
2586	June 22	6:57 a.m.	Ritter Deep
2633	June 26	8:32 a.m.	Station 3

C. Hauls 15-10 fathoms

2325	June 14	11:48 a.m.	Station 3
2358	June 15	5:39 a.m.	Station 2
2454	June 17	5:46 a.m.	Station 3
2470	June 17	8:20 a.m.	Station 3
2507	June 18	5:20 a.m.	Station 2
2520	June 18	7:04 a.m.	Station 2
2535	June 20	5:55 a.m.	Station 1
2554	June 20	8:50 a.m.	Station 1
2585	June 22	6:52 a.m.	Ritter Deep
2617	June 26	4:58 a.m.	Station 2
2632	June 26	8:30 a.m.	Station 3

D. Hauls 20-15 fathoms

Haul number	Date 1911	Time of day	Position
2324	June 14	11:44 a.m.	Station 3
2372	June 15	8:47 a.m.	Station 2
2468	June 17	8:18 a.m.	Station 3
2519	June 18	7:00 a.m.	Station 2
2553	June 20	8:45 a.m.	Station 1
2584	June 22	6:47 a.m.	Ritter Deep
2616	June 26	4:53 a.m.	Station 2
2631	June 26	8:20 a.m.	Station 3

E. Hauls 25-20 fathoms

2504	June 18	5:10 a.m.	Station 2
2533	June 20	5:48 a.m.	Station 1
2552	June 20	8:42 a.m.	Station 1
2583	June 22	6:44 a.m.	Ritter Deep
2630	June 26	8:15 a.m.	Station 2
2486	June 18	3:30 a.m.	Station 2

F. Hauls 30-25 fathoms

2532	June 20	5:42 a.m.	Station 1
2582	June 22	6:40 a.m.	Ritter Deep
2629	June 26	8:09 a.m.	Station 3

G. Hauls 40-30 fathoms

2628	June 26	8:03 a.m.	Station 2

H. Hauls 50-40 fathoms

2579	June 22	6:20 a.m.	Ritter Deep

Table 9, which follows, contains the data for the hauls with the open vertical net. The data for the following hauls will be found in table 34, p. 96 of Michael's paper:

1468, 1492, 1494, 1508, 1516, 1534, 1527, 1571, 1574.

These hauls, together with the ones listed in table 9, comprise all that I used.

TABLE 9

Data concerning hauls with the open vertical net. (Net A).

Haul number	Date	Time of day	Depth in fathoms	North Latitude	West Longitude
1109	June 21, 1906	6:00 a.m.	15–0	32° 51′.0	117° 19′.0
1171	June 29, 1906	6:40 a.m.	20–0	32° 51′.7	117° 16′.5
1161	June 29, 1906	5:30 a.m.	30–0	32° 51′.6	117° 17′.4
1099	June 20, 1906	5:40 a.m.	35–0	32° 51′.7	117° 17′.7
1128	June 26, 1906	5:15 a.m.	40–0	.....	.....
1207	July 5, 1906	7:00 a.m.	45–0	32° 51′.7	117° 18′.2
1087	June 19, 1906	5:30 a.m.	50–0	32° 52′.2	117° 17′.0
953	July 1, 1905	7:00 a.m.	55–0	32° 52′.0	117° 18′.7
1115	June 25, 1906	6:00 a.m.	60–0	32° 51′.6	117° 18′.8
1140	June 27, 1906	5:30 a.m.	60–0	32° 51′.5	117° 17′.6
1213	July 6, 1906	7:00 a.m.	60–0	32° 51′.2	117° 17′.1
1183	July 2, 1906	6:30 a.m.	65–0	32° 52′.3	117° 16′.7
1152	June 28, 1906	5:30 a.m.	70–0	32° 51′.8	117° 16′.7
886	June 21, 1905	.....	80–0	32° 52′.0	117° 18′.3
1193	July 3, 1906	6:30 a.m.	85–0	32° 52′.6	117° 18′.8
1237	July 7, 1906	6:00 a.m.	90–0	32° 51′.0	117° 18′.0
896	June 22, 1905	.....	100–0	32° 54′.1	117° 20′.0
928	June 28, 1905	4:00 p.m.	100–0	32° 53′.0	117° 18′.7
935	June 29, 1905	6:00 a.m.	100–0	32° 53′.6	117° 21′.1
939	June 30, 1905	5:00 a.m.	100–0	32° 52′.3	117° 19′.0
950	July 1, 1905	6:00 a.m.	100–0	32° 52′.6	117° 18′.8
979	July 8, 1905	6:00 a.m.	100–0	32° 51′.9	117° 18′.5
1094	June 19, 1906	3:30 p.m.	100–0	32° 52′.2	117° 17′.0
1267	July 13, 1906	10:30 a.m.	100–0	32° 48′.1	117° 19′.6
1354	July 23, 1906	11:00 a.m.	115–0	32° 52′.8	117° 21′.9
962	July 5, 1905	1:00 p.m.	118–0	32° 54′.6	117° 29′.2
1306	July 18, 1906	1:00 p.m.	150–0	32° 50′.9	117° 25′.5
1342	July 21, 1906	12:30 p.m.	150–0	32° 52′.5	117° 26′.5
1270	July 13, 1906	12:30 p.m.	155–0	32° 47′.4	117° 20′.8
1177	June 30, 1906	11:00 a.m.	160–0	32° 52′.8	117° 18′.1
1318	July 19, 1906	2:00 p.m.	170–0	32° 47′.5	117° 25′.0
1174	June 30, 1906	10:00 a.m.	185–0	32° 53′.5	117° 17′.7
1351	July 23, 1906	9:30 a.m.	215–0	32° 52′.9	117° 22′.2
1134	June 26, 1906	12:45 p.m.	285–0	32° 53′.4	117° 23′.6
1131	June 26, 1906	10:30 a.m.	275–0	32° 53′.4	117° 23′.6
1045	July 27, 1905	4:00 p.m.	300–0	32° 55′.7	117° 24′.9
1252	July 11, 1906	1:30 p.m.	310–0	32° 54′.8	117° 23′.0
1339	July 21, 1906	11:00 a.m.	310–0	32° 52′.6	117° 28′.2
1303	July 18, 1906	12:00 m.	315–0	32° 50′.9	117° 25′.5
1315	July 19, 1906	12:00 m.	320–0	32° 47′.5	117° 25′.0
1249	July 11, 1906	11:00 a.m.	325–0	32° 54′.8	117° 23′.0
1030	July 20, 1905	2:30 p.m.	400–0	San Clemente	
1528	July 2, 1908	11:45 a.m.	500–0	32° 58′.3	118° 14′.7
1075	Dec. 17, 1905	.....	600–0	San Clemente	

TABLE 10

List of Species and their Numbers occurring in Hauls with the Open Vertical Nets

Haul number	*Aetideopsis divaricata*	*Aetideopsis pacifica*	*Arietellus major*	*Arietellus setosus*	*Augaptilus lucidus*	*Augaptilus macrodus*	*Augaptilus rostratus*	*Calanus finmarchicus*	*Calanus gracilis*	*Calanus robustior*	*Candacia bipinnata*	*Chirundina streetsi*	*Disseta grandis*	*Eucalanus elongatus*	*Euchaeta californica*	*Euchaeta diegensis*	*Euchaeta dubia*	*Euchaeta media*	*Euchaeta propinqua*	*Euchaeta spinifer*
1571	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
1574	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
1109	......	......	......	......	......	......	......	110	......	......	......	......	......	300	......	......	......	......	......	......
1171	......	......	......	......	......	......	......	3	......	......	......	......	......	100	......	......	......	......	......	......
1161	......	......	......	......	......	......	......	30	......	......	......	......	......	100	......	......	......	......	......	......
1099	......	......	......	......	......	......	......	few	......	......	......	......	......	few	......	......	......	......	......	......
1128	......	......	......	......	......	......	......	50	......	......	......	......	......	350	......	......	......	......	......	......
1207	......	......	......	......	......	......	......	......	......	......	......	......	......	25	......	......	......	......	......	......
1087	......	......	......	......	......	......	......	6	......	......	......	......	......	10	......	......	......	......	......	......
953	......	......	......	......	......	......	......	40	......	......	......	......	......	100	......	......	......	......	......	......
1115	......	......	......	......	......	......	......	200	......	......	......	......	......	100	......	......	......	......	......	......
1140	1	......	......	......	......	......	......	500	......	......	......	......	......	500	......	1	......	......	......	......
1213	......	......	......	......	......	......	......	2	......	......	......	......	......	350	......	......	......	......	......	......
1183	......	......	......	......	......	......	......	5	......	......	......	......	......	100	......	......	......	......	......	......
1152	......	......	......	......	......	......	......	30	......	......	......	......	......	300	......	......	......	1	......	......
886	......	......	......	......	......	......	......	10000	......	......	......	......	......	50	......	......	......	......	......	......
1193	......	......	......	......	......	......	......	12	......	......	......	......	......	300	......	......	......	......	......	......
1237	......	......	......	......	......	......	......	25	......	......	......	......	......	500	......	......	......	......	......	......
896	......	......	......	......	......	......	......	4000	......	......	......	......	......	300	......	......	......	......	......	......
928	......	......	......	......	......	......	......	125	......	......	......	......	......	200	......	......	......	......	......	......
935	......	......	......	......	......	......	......	100	......	......	......	......	......	200	......	......	......	1	......	......
939	......	......	......	......	......	......	......	300	......	......	......	......	......	100	......	2	......	1	......	......
950	......	......	......	......	......	......	......	250	......	......	......	......	......	150	......	......	......	......	......	......
979	......	......	......	......	......	......	......	8000	......	......	......	......	......	400	......	......	......	......	......	......
1094	......	......	......	......	......	......	......	many	......	......	1	......	......	many	......	......	......	......	......	......
1267	......	......	......	......	......	......	......	5500	......	......	1	......	......	10800	......	......	......	......	......	......
1354	......	......	......	......	......	......	......	......	......	......	......	......	......	7240	......	......	......	1	......	......
962	......	......	......	......	......	......	......	300	......	......	......	......	......	100	......	......	......	......	......	......
1306	......	......	......	......	......	......	......	15	......	......	......	......	......	13000	......	......	......	2	......	......
1342	......	......	......	......	......	......	......	500	2	......	1	......	......	14000	......	2	......	2	......	......
1508	......	......	......	......	......	......	......	170	......	......	......	......	......	259	......	......	......	......	......	......
1524	......	......	......	......	......	......	......	2	......	......	......	......	......	......	......	......	......	......	......	......
1270	......	......	......	......	......	......	......	7500	......	......	......	......	......	12500	......	......	......	2	......	......
1177	......	......	......	......	......	......	......	few	......	......	......	......	......	2000	......	1	......	......	......	......
1318	......	......	1	......	......	......	......	3000	......	......	......	......	......	22000	......	1	......	7	......	......
1492	......	......	......	......	......	......	......	3	......	......	......	2	......	......	......	......	......	......	......	......
1494	......	......	......	......	......	......	......	60	......	......	......	......	......	26	......	......	......	......	......	......
1174	......	......	......	......	......	......	......	few	......	......	......	......	......	2000	......	......	......	......	......	......
1351	......	......	......	......	......	......	......	1400	......	......	......	......	......	11200	......	......	......	......	......	......
1516	......	......	......	......	......	......	......	402	......	......	......	......	......	42	......	......	......	......	......	......
1134	......	......	......	......	......	......	......	few	......	......	......	......	......	many	1	......	......	1	......	......
1131	......	......	......	......	......	......	......	40	......	......	......	......	......	500	......	1	1	......	......	......
1468	......	......	......	......	......	......	......	120	......	......	......	1	......	93	1	......	......	......	......	1
1045	......	......	......	......	......	......	......	5000	......	......	......	......	......	4000	......	......	......	4	......	......
1252	3	1	1	......	......	......	......	1000	2	......	......	......	......	22500	......	3	......	4	......	2
1339	......	......	......	......	1	......	......	250	......	......	......	1	......	7000	2	1	......	1	......	......
1303	......	......	......	......	......	......	1	800	1	......	......	......	......	6000	......	......	......	1	......	......
1315	......	4	1	......	......	......	1	1700	......	......	2	1	......	17000	......	3	1	......	......	......
1249	......	......	......	......	......	1	......	700	......	......	......	......	......	15000	1	1	......	4	......	1
1030	......	......	......	......	......	......	2	4700	......	1	......	4	......	5800	1	1	2	5	......	4
1527	......	......	......	......	......	......	......	9	......	......	......	2	......	45	......	1	......	......	......	......
1528	......	......	......	......	......	......	......	3	......	......	......	1	......	58	4	......	......	......	......	1
1075	......	......	......	1	......	......	......	1500	......	......	......	......	6	2400	......	......	2	......	1	......

Haul number	*Euchaeta spinosa*	*Euchaeta tenuis*	*Euchaeta tonsa*	*Euchirella curticauda*	*Euchirella galeata*	*Euchirella propria*	*Euchirella pulchra*	*Euchirella rostrata*	*Euchirella simplex*	*Euchirella truncata*	*Gaetanus brevicornis*	*Gaetanus clarus*	*Gaetanus secundus*	*Gaetanus unicornis*	*Gaidius pungens*	*Heterorhabdus longicornis*	*Heterorhabdus spinifrons*	*Labidocera trispinosa*	*Metridia atra*	*Metridia ignota*	*Metridia lucens*	*Metridia princeps*
1571	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
1574	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
1109	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	25	......	......	......	......
1171	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	11	......	......	......	......
1161	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	3	......	......	......	......
1099	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
1128	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	50	......	......	......	......
1207	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......
1087	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
953	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	120	......	......	......	......
1115	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	30	......	......	......	......
1140	3	......	......	......	......	......	......	2	......	......	......	......	......	......	......	......	......	100	......	......	......	......
1213	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	2	......	......	......	......
1183	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	10	......	......	......	......
1152	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	......
886	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
1193	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	2	......	......	......	......
1237	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
896	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
928	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
935	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
939	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
950	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	40	......	......	......	......
979	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	10000	......	......	......	......
1094	......	......	......	......	......	......	......	3	......	......	......	......	......	......	......	......	......	......	......	......	few	......
1267	3	......	......	......	......	......	......	11	......	......	......	......	......	......	......	......	......	300	......	......	......	......
1354	......	......	......	......	......	......	......	6	......	......	......	......	......	......	......	......	......	......	......	......	......	......
962	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	125	......	......	......	......
1306	1	......	......	......	......	......	1	7	2	1	......	......	......	......	......	......	......	......	......	......	......	......
1342	3	......	......	......	......	1	5	20	......	......	......	......	1	......	......	......	......	......	......	......	......	......
1508	......	......	1	......	1	......	4	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......
1524	......	1	......	......	......	......	......	1	......	......	......	......	......	......	1	......	......	......	......	......	......	......
1270	4	......	......	......	......	......	......	18	......	......	......	......	......	......	......	......	......	3	......	......	......	......
1177	4	......	......	......	1	......	2	6	......	......	......	......	......	......	......	......	......	few	......	......	......	......
1318	4	......	......	......	12	1	7	7	......	......	......	......	5	......	......	1	......	......	......	......	......	......
1492	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
1494	......	......	1	......	......	......	1	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......
1174	1	......	1	......	......	......	3	4	......	......	......	......	......	......	......	......	......	few	......	......	......	......
1351	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
1516	1	......	......	......	......	......	......	2	......	1	......	......	......	1	3	......	......	......	......	......	......	......
1134	......	......	1	1	4	......	3	15	......	......	......	......	......	2	......	......	......	......	......	......	......	......
1131	......	......	......	......	......	......	1	1	......	......	......	......	......	......	1	......	......	......	......	......	100	4
1468	......	......	1	......	1	......	3	2	......	......	......	......	......	1	......	......	......	......	......	......	......	......
1045	1	2	7	......	5	......	16	4	......	......	2	2	......	8	6	......	......	......	......	......	......	......
1252	2	......	14	......	9	......	18	28	......	......	......	1	......	8	20	2	......	......	......	......	......	......
1339	......	......	4	2	......	......	9	9	......	......	......	......	1	2	3	......	......	......	......	......	......	......
1303	......	......	2	1	2	......	6	3	1	1	2	......	......	7	12	......	......	......	3	......	3	3
1315	2	......	5	2	7	2	11	3	......	1	1	1	1	2	19	1	......	......	......	......	1	8
1249	3	......	5	......	8	......	26	6	......	......	......	......	2	4	6	......	......	......	......	......	......	......
1030	......	......	15	2	4	......	16	......	......	......	1	......	......	......	4	......	1	......	3	1	......	12
1527	......	......	2	......	......	......	2	1	......	......	2	......	......	1	1	......	......	......	4	......	......	4
1528	1	......	18	1	......	......	......	1	......	......	3	......	......	2	6	......	......	......	2	4	......	2
1075	2	......	2	......	10	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	2

Onchocalanus latus	*Paraugaptilus buchani*	*Phyllopus integer*	*Pleuromamma abdominalis*	*Pleuromamma gracilis*	*Pleuromamma quadrungulata*	*Pleuromamma xiphias*	*Pontellopsis occidentalis*	*Rhincalanus nasutus*	*Scolecithrix frontalis*	*Scolecithrix inornata*	*Scolecithrix magna*	*Scolecithrix persecans*	*Scolecithrix pulchra*	*Scolecithrix vorax*	*Undeuchaeta bispinosa*	*Undeuchaeta incisa*	*Undeuchaeta minor*	*Xanthocalanus similis*	Haul number
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1571
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1574
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1109
......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1171
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1161
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1099
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1128
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1207
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1087
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	953
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1115
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1140
......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	1213
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1183
......	......	......	3	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1152
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	886
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1193
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1237
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	896
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	928
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	935
......	......	......	3	......	......	2	......	......	......	......	......	......	......	......	1	......	......	......	939
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	950
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	979
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1094
......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	1267
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1354
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	962
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1306
......	......	......	16	......	......	......	......	......	......	......	......	5	......	......	......	......	......	......	1342
......	......	......	......	......	3	1	......	......	1	......	......	6	......	......	4	......	......	......	1508
......	......	......	......	......	2	......	5	......	......	......	......	......	......	......	1	......	......	......	1524
......	......	......	......	......	......	......	......	......	......	......	......	2	......	......	1	......	1	......	1270
......	......	......	......	......	1	......	......	......	......	......	......	......	......	......	3	......	......	......	1177
1	......	......	3	......	1	......	......	......	......	......	......	7	......	......	......	......	......	......	1318
......	......	......	......	......	2	......	......	......	1	......	......	......	......	......	......	......	......	......	1492
......	......	......	......	......	4	......	......	......	......	......	......	1	......	......	......	......	......	......	1494
......	......	1	......	......	......	2	......	......	......	......	......	......	......	......	4	......	......	......	1174
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1351
......	......	......	......	......	4	......	......	......	......	......	......	8	......	......	1	......	......	......	1516
1	......	1	few	......	......	......	......	......	1	......	......	2	1	......	5	......	......	......	1134
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	1131
......	......	......	present	......	10	2	......	......	5	......	1	4	......	......	7	......	......	......	1468
......	......	1	7	......	2	2	1	1	4	......	5	20	......	......	51	......	......	......	1045
......	......	4	10	......	32	4	......	3	2	......	2	24	......	1	26	1	......	......	1252
......	......	1	10	......	14	6	......	......	2	......	2	10	......	......	15	1	......	......	1339
......	1	4	1	......	8	2	......	......	1	2	......	3	......	......	4	......	......	......	1303
......	1	10	6	......	19	3	......	......	4	1	1	7	......	......	25	......	......	......	1315
......	......	7	4	......	3	2	......	few	1	......	......	3	......	......	13	......	......	......	1249
......	......	......	4	......	30	1	......	......	......	2	3	11	......	......	36	......	......	1	1030
......	......	......	2	......	8	5	......	1	2	1	2	......	......	......	3	......	......	......	1527
......	......	......	......	......	19	9	......	......	11	1	2	13	......	......	11	......	......	......	1528
......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	5	......	......	......	1075

[To face page 279]

The list of species as they occurred in the open vertical hauls is given in table 10, which follows.

No attempts have been made to standardise the catches of the different nets. It would be advisable to attempt this if we were studying the action of the types of nets used. But since we are primarily concerned with the biology of the copepods, and because certain facts are obtainable from our data without correlating, each sort of net is considered by itself. One cannot fail to notice that the catches of the horizontal and vertical closing nets do not always agree closely, particularly as to the location of the region of greatest abundance. Yet all the nets show a rather striking correspondence in regard to certain general features of the behavior of the Copepoda.

It does not seem that standardisation of net catches with each other would really be of much value in view of the results of hauling with similar nets at the same time and almost in the same place. The idea that such standardising is valuable doubtless grew out of the belief that plankton animals are uniformly distributed in the water. But such work as that of Herdman (1906), Herdman, Scott and Dakin (1909), or that of Michael (1911) has shown that distribution is irregular. Instances of this could be given almost without number in regard to the distribution of the copepods of this region. Standardisation would have to be based on factors that depend on the organisms themselves, that is on biological factors in cases where similar nets used at the same time and in as nearly the same manner as possible give very different results. It is likely, therefore, that attempting to adjust for different nets in regard to distance and rate of hauling, amount of water filtered, and like factors is at least unnecessary when the nets are used at different times and under different conditions. We may reasonably expect that, if we deal with a large number of hauls well distributed over several months and through the twenty-four hours, we shall obtain results of worth in regard to the relation of the organisms to their environment.

A possible method of standardising would be to allow for the difference in area of the mouths of nets. This was done in two earlier papers (Esterly, 1911a, 1911b), but my experience

has led me to believe that such a method is practically valueless. In this paper numbers of specimens taken with different nets are not adjusted to each other and allowance should be made for that fact. The effect of certain environmental conditions is plain even if we do not know, from the number of animals taken with a given net, the number that might have been expected under the same conditions but with another net. Accordingly, I have followed the plan of considering the distribution of various species as shown by each of the four sorts of nets used, the catches with the different vertical closing nets being combined.

Nineteen species have been chosen for a detailed study of distribution. The selection was based purely upon frequency of occurrence, for a form must be found reasonably often to make it profitable to study its distribution. It is believed that all of the species listed in table 11 were taken often enough to furnish a reliable basis for such a study. This table explains itself, but it should be noted that the lower numbers in each column and in lines 1–18 give the number of hauls in which the species was found.

TABLE 11

List of species studied singly, and their occurrence in different sorts of hauls

	A Surface	B Horiz. closing	C Vertical closing	D Vertical open	E Totals
Total number of hauls	203	114	310	53	680
Name of species	Numbers of animals and successful hauls				
1. *Calanus finmarchicus*	20480	1875	2927	57731	82013
	117	75	171	49	412
2. *Eucalanus elongatus*	2427	1050	2049	179499	185026
	55	60	193	49	357
3. *Euchaeta tonsa*	.....	11	16	72	99
	.....	4	5	15	24
4. *Euchirella galeata*	.....	4	26	72	102
	.....	3	10	15	28
5. *Euchirella pulchra*	18	33	107	135	293
	7	10	17	18	52
6. *Euchirella rostrata*	19	4	4	171	198
	13	4	3	27	47
7. *Gaetanus unicornis*	.....	6	13	35	54
	.....	3	5	11	19
8. *Gaidius pungens*	4	148	786	83	1021
	3	12	26	13	54
9. *Labidocera trispinosa*	3466	.....	21	11822	15309
	28	.....	11	18	57
10. *Metridia lucens*	38190	740	5974	104+	45008
	28	28	80	4	140
11. *Pleuromamma abdominalis*	372	114	110	70	666
	19	14	28	15	76
12. *Pleuromamma gracilis*	213	1	316	1	531
	7	1	6	1	15
13. *Pleuromamma quadrungulata*	3	56	276	166	501
	2	16	21	18	57
14. *Pleuromamma xiphias*	.....	12	29	12	53
	.....	7	11	7	25
15. *Rhincalanus nasutus*	54	9	142	7+	212
	11	8	46	6	71
16. *Scolecithrix frontalis*	.....	12	46	25	83
	.....	5	13	12	30
17. *Scolecithrix magna*	.....	3	9	18	30
	.....	3	5	8	16
18. *Scolecithrix persecans*	3	20	551	127	701
	2	10	27	17	56
19. *Undeuchaeta bispinosa*	25	36	85	116	262
	5	11	14	20	50

In considering the distribution and movements of the species named in table 11, the data for the four styles of nets have been studied separately, and arranged so. In all other cases except hauls with vertical closing nets the number of animals has been reckoned on the basis of a haul one hour in length; such numbers are called hourly averages or number per hour and are obtained by dividing the total number of animals by the total number of hours. The term "haul frequency" means the percentage of *successful hauls*—the ratio between hauls in which the species was taken and the total number of hauls. "Time frequency" is the percentage of hours of successful hauling or the ratio between the time occupied by hauls in which the species was taken and the total time spent in hauling. Frequency has no reference to abundance of animals; the frequency would be the same for a given number of hauls whether one animal or a hundred were taken in each haul.

The whole day has been divided into twelve periods of two hours each and the time from 6 a.m. to 6 p.m. is referred to as "day," while that from 6 p.m. to 6 a.m. is called "night." These designations are more or less arbitrary since they have no necessary relation to sunrise or sunset.

Distribution of *Calanus finmarchicus*.

According to the statements of Sars (1904, p. 11) this form should be referred to as *C. helgolandicus*. It seems to me, however, that there can be no doubt that the species is *C. finmarchicus*, and Wolfenden (1904, p. 126) is of the opinion that the factors on which Sars bases the distinction are too inconstant to be admissible.

This species was found in a larger proportion of all hauls than any other, being taken in 412 out of 680; the haul frequency is 61. I have discussed the vertical distribution of *Calanus* on a basis of 23 surface hauls and 73 hauls with the Kofoid closing net (Esterly, 1911b) and while there are 114 of the latter hauls available now it is unnecessary to repeat the discussion, since the additional number of hauls does not affect the conclusions arrived at before. This is also true of the surface hauls in a general way, but the larger number of hauls that can

be included in this study enables us to arrange the data in a much more useful manner than was done previously. Table 12, which follows, shows how *Calanus* is distributed at the surface according to the time of day.

TABLE 12

Distribution of *Calanus finmarchicus* at the surface, by two-hour periods through the day. Net A.

	Time of Day a.m.	No. of hauls Total A	Success. B	No. of hours Total C	Success. D	No. of animals Total E	Per hour F	Frequency Haul G	Time H
1.	6–8	35	15	27.2	12.3	2491	91	43	41
2.	8–10	21	9	20.2	11.4	1640	80	43	51
3.	10–12	14	7	9.8	6.1	103	10	50	62
	p.m.								
4.	12–2	14	8	9.0	6.0	92	10	57	66
5.	2–4	14	5	9.7	3.5	663	68.5	36	36
6.	4–6	13	6	9.9	5.0	900	69.2	46	51
7.	6–8	30	23	19.9	15.4	3643	175.0	74	73
8.	8–10	8	8	4.4	4.4	4285	973	100	100
9.	10–12	1	1	2.8	2.8	3825	1375	100	100
	a.m.								
10.	12–2	3	3	2.6	2.6	151	58	100	100
11.	2–4	8	8	12.0	12.0	1177	97.2	100	100
12.	4–6	41	25	26.6	13.0	514	19.3	61	53

Table 13 is a summary of table 12, and is self-explanatory.

TABLE 13

Summary of table 12

	Day	Night
1. Total number of hauls	111	92
2. Number of successful hauls	50	67
3. Total number of hours	85.6	69.5
4. Number of successful hours	43.3	47.7
5. Total number of animals	5889	14574
6. Average per hour	6.6	218.0
7. Haul frequency	45	75
8. Time frequency	50	75

This table shows in a very striking manner the greater abundance and frequency at night (lines 5–8), though there are not so many night as day hauls, nor so many hours spent

in hauling at night. From table 12, lines 8 and 9, it is evident that *Calanus* is found in greatest abundance at the surface during the four hours preceding midnight; this is a fact without taking account of the possible factors that operate to produce the result observed. It seems very likely that this general condition is due to diurnal migrating. In column F of table 12 the lowest hourly averages are in lines 3 and 4, which include the two hours before and after midday. In the afternoon and evening up to midnight (lines 5–9) the averages increase, after which there is a sharp drop in the numbers per hour. It should be noted that the highest frequencies are obtained in night collecting (columns G, H, lines 7–11) during the hours when the animals are most abundant. The number of hauls from 8 a.m. to 4 p.m. is relatively small, but there is certainly some significance to the fact that every haul made during those hours took the animals. It is noticeable that when the hourly average is higher the frequencies may be lower and vice versa (cf. columns F, G and H, lines 4 and 6).

Michael (1911, p. 116) found this to be true, also, and has given a discussion of possible reasons for it. I cannot add to his discussion, but the general facts of distribution are beyond dispute both as regards *Sagitta bipunctata* and *Calanus finmarchicus*.

The following propositions may be regarded as well established by the data in tables 2 and 13:

1. As the light increases during the morning the averages per hour decrease.

2. As the light decreases toward evening the hourly averages increase up to a certain time, after which they decrease. (See fig. 1).

At this point it should be noted that following the night maximum the decrease in abundance begins before the light increases; this matter was brought out in a former paper (Esterly, 1911b) but is a good deal more evident now on the basis of a much larger number of hauls. The conclusion from this is, evidently, that an increase in the intensity of light is not the only cause of the downward movement from the surface.

The fact of diurnal migrating was clearly shown by hauls with the Kofoid net made in 1909. The discussion of those hauls, as already stated, is in a separate paper (Esterly, 1911b) and will not be repeated here. Table 14, which follows, is derived from the data obtained from hauls with the vertical closing nets. The hauls with these nets are not well distributed through the twenty-four hours: there are no hauls between

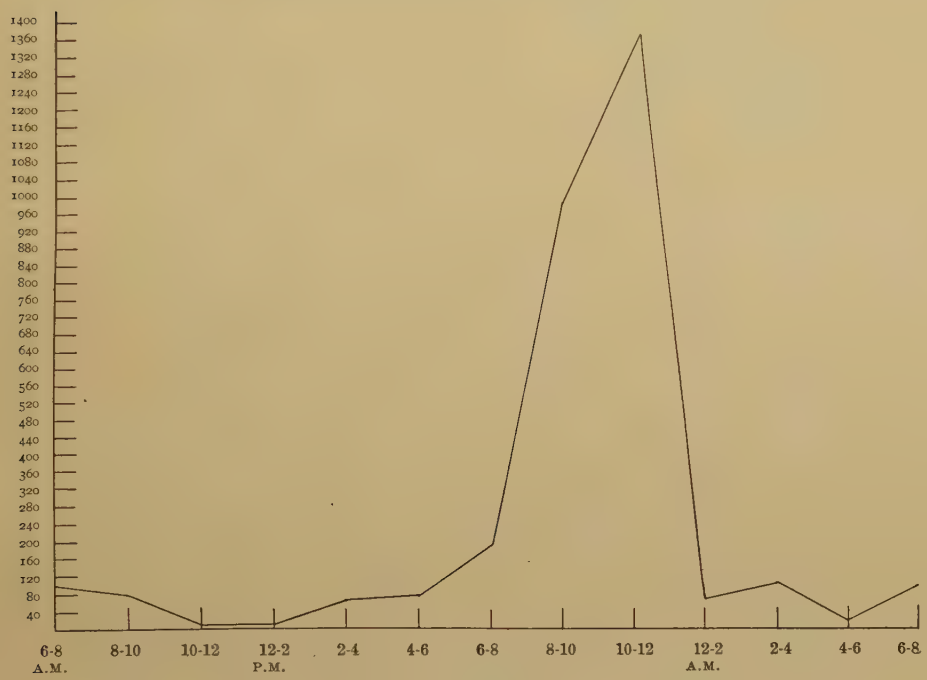

Fig. 1. *Calanus finmarchicus.* Variations in numbers per hour at surface according to time of day. Data in table 12.

8 p.m. and 2 a.m., and none between 6 and 8 p.m. above 50 fathoms; the day hauling was done between 6 and 12 a.m. and 4–6 p.m., there being no collections from 12 o'clock noon to 4 p.m. The frequencies in table 14 as in all others dealing with the vertical closing nets are "haul frequencies." "Hour frequency" would be practically meaningless, since the nets are drawn at the same rate in all hauls. The averages expressing abundance are "per fathom" for the same reasons.

TABLE 14

Distribution of *Calanus finmarchicus* as shown by vertical closing nets

	Depth in fathoms	Day 6-12 a.m., 4-6 p.m. Hauls Total A	Hauls Success. B	Animals Total C	Animals Per fathom D	Freq. E	Night 2-6 a.m., 6-8 p.m. (below 50 f.) Hauls Total F	Hauls Success. G	Animals Total H	Animals Per fathom I	Freq. J
1.	5–0	15	3	17	3.4	20	14	6	27	5.4	43
2.	10–5	15	5	32	6.4	33	14	5	49	9.9	36
3.	15–10	15	5	42	8.4	33	15	7	99	19.8	47
4.	20–15	15	4	21	4.2	27	15	8	75	15.0	53
5.	25–20	15	5	10	2.0	33	14	9	65	13.0	64
6.	30–25	17	7	20	4.0	41	14	10	98	19.6	71
7.	40–30	14	7	40	4.0	50	14	12	52	5.2	86
8.	50–40	16	6	48	4.8	37	15	12	84	8.4	80
9.	75–50	17	11	393	15.7	58	16	14	398	15.7	88
10.	100–75	6	4	143	5.7	66	3	3	240	9.6	66
11.	150–100	6	5	225	4.5	83	4	4	114	2.8	100
12.	200–150	6	6	242	4.9	100	3	3	87	1.7	66
13.	250–200	6	6	22	4.4	100	1	0	0	0.0	0
14.	300–250	4	2	58	1.6	50	1	1	1	0.2	100

This table shows that the region of greatest abundance during the day is between 50 and 75 fathoms (columns C and D, line 9). It is to be noted, however, that the greatest frequencies are between 150 and 250 fathoms (column E, lines 12 and 13), where the animals were taken in each of twelve hauls. It seems to me that this is a case where one must endeavor to estimate on the basis both of the abundance and the frequency.

During the night there appear to be two plurima, one at 10–15 fathoms and one at 30–25 (columns H and I, lines 3 and 6), but the abundance at 75–50 fathoms is close to the others.

Neither the day nor the night plurimum with the vertical closing nets corresponds to those found with the horizontal closing net. The latter appears to encounter the animals most abundantly at about 200 fathoms during the day, while the plurimum between 6 and 10 p.m. is at 100 fathoms, at midnight between 5 and 10 fathoms and from 4 to 6 a.m. it is at 100 fathoms again (Esterly, 1911b).

I am unable to reconcile the discrepancies between the action of the two sorts of nets. It seems certain that the Kofoid net will give more reliable results and it is possible that if the vertical hauls were distributed evenly through the day and night the results of using them would be more in agreement with those obtained by the horizontal nets. It may be said that the plurimum with the vertical nets between 6 and 8 p.m. is overwhelmingly between 75 and 100 fathoms (this is not shown in table 14), while between 4 and 6 a.m. the plurimum is plainly between 50 and 75 fathoms. These regions correspond fairly well with the plurima at the same times as shown by the Kofoid net (see preceding paragraph). Furthermore, in table 14, line 9, columns C and D, and H and I, it will be seen that the total number of animals and the number per fathom is the same for night and day hauls between 75 and 50 fathoms. It is noticeable that the vertical hauls at night were made in very early evening (6–8 p.m. or early morning 2–6 a.m.) and these are the times when the Kofoid net showed the maxima at 100 fathoms. It can at least be said that there is an indication in the data from the vertical nets of the same behavior on the part of the animals as is shown by the horizontal net.

Although the distribution of the vertical closing hauls as to time of day is not all that can be desired, the evidence points toward a diurnal migration of the organisms. Inspection of table 14 shows that above 50 fathoms the numbers of animals taken are smaller by day and larger by night (columns C, D, H, I, lines 1–8). Below 50 fathoms the day numbers are larger than above that level (columns C and D, lines 1–8, 9–12). Accordingly, we may take 50 fathoms as a sort of dividing line and arrange a table like that following, which is a summary of the data in table 14.

TABLE 15

Summary of results in table 14

	Specimens per fathom		Total hauls		Success. Hauls		Frequency	
	Day	Night	Day	Night	Day	Night	Day	Night
Between 0 and 50 fathoms	4.6	10.4	122	115	42	69	34	46
Between 50 and 200 fathoms	7.0	5.6	35	26	26	24	70	93

It is fair to conclude from table 15 that the vertical nets indicate that there is a movement away from the upper water during the day, and a movement away from deeper water at night. It is true that the differences between day and night hauls as shown in table 15 are not great but taken in connection with the results from surface and horizontal closing collections, they are suggestive. Emphasis should be laid on the fact that there are no vertical hauls above 50 fathoms and at night before 2 a.m., and that it is between 8 and 12 p.m. that the animals are obtained in greatest abundance with the surface net; and furthermore that during the same time and above 50 fathoms they were taken in largest numbers by the Kofoid net. It is to be expected that with these omissions the results of collecting with the vertical nets will not be so clear as with the others, and that the differences in abundance between day and night will not be so great. At any rate, judging from the data available at this time, there is evidence from all the nets that *Calanus* performs diurnal migrations. This conclusion should not be cast aside because the three types of nets do not agree in all respects, for a larger number of hauls more uniformly distributed as to time will probably smooth out the irregularities.

Distribution with regard to temperature.—In considering the relation between temperature and the occurrence of *Calanus*, I used 130 surface hauls made in June, July, August and September. These were chosen in order to do away with possible seasonal changes, for the temperatures in the months named run about the same. Temperatures for closing net hauls are not known.

The results reached are very irregular. As an indication of this table 16 has been constructed. It contains the ten hauls of the 130 that took the largest number of specimens; these are all night hauls in either June or July. The hauls were made between the hours in the column at the left.

TABLE 16

Two-hour period	Temperature	Number of animals per hour
6–8 p.m.	16°.3	2900
2–4 a.m.	16°.7	930
8–10 p.m.	17°.6	1795
4–6 a.m.	18°.7	1635
10–12 p.m.	19°.0	1362
2–4 a.m.	19°.2	66
6–8 p.m.	20°.3	801
8–10 p.m.	20°.5	1780
8–10 p.m.	20°.5	4050
6–8 p.m.	22°.2	1020

It is difficult to detect any relation between temperature and abundance in this table. Most of the large hauls were made before 10 p.m. but the temperatures at those times ranged from the lowest to the highest. In addition to the hauls in table 16, four others may be noted which were made in February of two different years: One haul, between 6 and 8 a.m. took 4600 per hour at a temperature of 14°.2; another, between 2 and 4 p.m. took 404 per hour at 14°.2; a third, made between 4 and 6 p.m. captured at the rate of 1300 per hour when the temperature was 13°.8; the fourth, between 6 and 8 p.m. took 360 at a temperature of 13°.8. These hauls show that at low temperatures there is about as much variation in abundance as at medium and high temperatures.

If all the surface hauls are arranged in a table there is no marked correlation between surface temperatures and number of specimens. Such a table is found in the one following (table 17). It is arranged on the same plan as table 14.

TABLE 17

Distribution of *Calanus* at surface with regard to temperature

	Temperature	No. of hauls Total 1	No. of hauls Success. 2	No. of hours Total 3	No. of hours Success. 4	No. of animals Total 5	No. of animals Per hour 6	Frequency Haul 7	Frequency Time 8
	A. 4-8 a.m.								
1.	16.0–17.0	10	9	10.5	5.9	152	12.7	56	56
2.	17.1–18.0	15	3	14.0	3.7	11	.8	20	24
3.	18.1–19.0	10	1	6.4	.3	546	124.2	10	4
4.	19.1–21.5	14	10	8.1	5.2	162	54.0	71	64
	B. 8 a.m.-4 p.m.								
1.	16.0–17.0	10	3	8.1	2.0	3	.4	30	25
2.	17.1–18.0	8	1	4.5	.3	8	1.8	12	6
3.	18.1–19.0	6	1	2.5	.2	7	2.8	16	5
4.	19.1–21.5	7	2	6.8	2.3	26	3.8	29	34
	C. 8-10 p.m.								
1.	16.0–17.0	1	1	.4	.4	1209	2900.0	100	100
2.	17.1–18.0	6	4	5.6	3.6	1999	334.0	66	64
3.	18.1–19.0	9	4	5.5	1.5	141	20.6	44	28
4.	19.1–21.5	17	13	8.4	6.2	3279	390	77	74
	D. 10 p.m.-4 a.m.								
1.	16.0–17.0	4	4	3.4	3.4	757	210	100	100
2.	17.1–18.0	3	3	2.7	2.7	133	49	100	100
3.	18.1–19.0	3	3	4.7	4.7	3865	964	100	100
4.	19.1–21.5	1	1	5.5	5.5	367	66	100	100

A summary of this table is given in table 18, which will make it easier to bring together the results of table 17.

TABLE 18

Summary of table 17

	Temperature	No. of hauls Total A	No. of hauls Success. B	No. of hours Total C	No. of hours Success. D	No. of animals Total E	No. of animals Per hour F	Frequency Haul G	Frequency Time H
1.	16°.0–17°.0	31	17	22.4	11.7	1571	70.6	55	47
2.	17°.1–18°.0	32	11	27.8	10.0	2151	77.3	31	36
3.	18°.1–19°.0	28	11	19.1	8.7	4559	238.0	39	46
4.	19°.1–21°.5	39	26	29.8	19.2	3834	125.0	67	64
	Time of day								
5.	4 a.m.–8 a.m.	55	23	39.0	14.8	871	22.0	42	38
6.	8 a.m.–4 p.m.	31	7	21.9	6.7	54	2.4	22	30
7.	4–10 p.m.	33	24	19.9	13.7	6628	303.0	73	69
8.	10 p.m.–4 a.m.	11	11	16.3	16.3	5122	305.0	100	100

It is plain from table 18 that the highest hourly average is obtained at a temperature between 18°.1 and 19 (column F, line 3), while the frequencies are highest for the highest temperatures (columns G and H, line 4). In table 17 the averages per hour are highest when the temperature is between 18°.1 and 19° in two cases out of a possible four (column 6, line 3 in sections A and D; so far it may be said that there is an apparent correlation between abundance at the surface and that range of temperature. This holds for early morning (section A) and late night (section D). It is not easy to say whether or not the general lack of correspondence between abundance and frequency is significant. Michael (1911, p. 139) found that these correspond rather closely.

It would seem that if temperature is a very effective agent in determining distribution there would be some sort of regularity in the arrangement of hourly averages with respect to temperature; that is, in the present case, we should expect the highest average to be at the same temperature whatever the time of day. This is obviously not the case in table 17, where, in section B, columns 5 and 6, there is a regular series for the abundance from the lowest to the highest temperatures. The order of abundance in relation to temperature varies in all the sections of the table. If table 18 is considered from all points of view, it is very difficult to discover a constant relation between temperature and abundance; the conclusion is that this factor within the limits of surface variation revealed by our data has but a slight effect, if any, in determining the distribution of *Calanus*, and this conclusion is strengthened by the data in table 16.

It is true that table 18 shows the animals to be least abundant at a low temperature and that there is an increase in abundance to the maximum at 18°.1–19° (columns E and F, lines 1–3). This table, however, summarises the distribution with regard to temperature without the possible effects of light. This is impossible under natural conditions and we know that the abundance is much greater at certain times of day than at others. It seems to me that the apparent relation pointed out between the temperatures 18°.1–19° and abundance is really

misleading in that it does not clarify matters. The data concerning distribution and temperatures are given for what they are worth; they do not seem to show that temperature is important in determining the distribution of *Calanus* at the surface. There is doubtless a temperature that may be called usual at the region of maximum abundance during the day, but there is no evidence that *Calanus* seeks that depth because of the temperature. In view of the movements performed by the species, it is difficult to imagine the part that temperature really has in the life of these animals. The bulk of the population periodically leaves a region where the temperature is about 9 degrees on the average and moves into water where the average temperature is about 17 degrees. The temperature does not vary periodically or constantly enough to lead us to consider its changes as the causes of the migrations, and it is very probable that there is some other cause. The variations in the intensity of light are both constant and periodical, and it is my belief that light is the primary cause of the movements of this species and also the main factor in determining its vertical distribution.

Distribution with regard to salinity.—The salinity is known for 71 surface hauls made in June, July, August and September, and these hauls alone will be considered because of the desirability of eliminating seasonal changes. This number of hauls is rather small, but table 19 will give some idea of the abundance of animals at certain salinities and times of day.

TABLE 19

Distribution of *Calanus* at surface with regard to salinity

	Salinity	No. of hauls Total	No. of hauls Success.	No. of hours Total	No. of hours Success.	No. of animals Total	No. of animals Per hour	Frequency Haul	Frequency Time
		1	2	3	4	5	6	7	8
	A. 4-8 a.m.								
1.	33.604 or less	10	3	9.0	3.2	11	1.2	30	35
2.	33.605–33.648	2	2	.8	.8	31	3.9	100	100
3.	33.649 or more	11	5	6.4	3.8	689	108.0	45	59
	B. 8 a.m.-4 p. m.								
1.	33.604 or less	6	2	4.3	1.1	11	2.6	33	25
2.	33.605–33.648	5	0	3.2	0.0	0	0.0	0	0
3.	33.649 or more	9	3	7.0	2.3	37	5.3	33	33
	C. 4 p.m.-10 p.m.								
1.	33.604 or less	11	9	6.0	5.4	4669	778.1	82	90
2.	33.605–33.648	8	5	4.2	3.0	954	226.0	62	71
3.	33.649 or more	7	4	4.4	3.6	293	66.5	57	82
	D. 10 p.m.-4 a.m.								
1.	33.604 or less	0	0	0.0	0.0	0	0.0	0	0
2.	33.605–33.648	1	1	2.8	2.8	3825	1368.0	100	100
3.	33.649 or more	2	2	5.7	5.7	378	61.3	100	100

TABLE 20

Summary of table 19

	Salinity	No. of hauls Total	No. of hauls Success.	No. of hours Total	No. of hours Success.	No. of animals Total	No. of animals Per hour	Frequency Haul	Frequency Time
		A	B	C	D	E	F	G	H
1.	33.604 or less	27	14	19.3	9.7	4691	271.0	82	50
2.	33.605–33.648	16	8	11.0	6.6	4810	437.2	50	60
3.	33.649 or more	29	14	23.5	18.6	397	16.7	48	81

In table 20, which deals with distribution in relation to salinity apart from time of day, we see that the highest hourly average (column F) is when the salinity is between 33.605 and 33.648 (line 2); the highest haul frequency is at a salinity 33.604 or less and the highest time frequency at a salinity of 33.649 or more.

In table 19 the greatest averages per hour (column 6) are at the highest densities in two cases out of four (line 3, sections A and B). In other words, the animals are most abundant during brightest daylight (8 a.m.–4 p.m.) and early morning (4 a.m.–8 a.m.) at a salinity of 33.649 or more. But they are most abundant and most frequent during twilight hauling when the salinity is lowest (section C, line 1), and during late night (section D, line 2) at a salinity of 33.605–33.648. It seems to me that such an erratic distribution of abundance in respect to salinity can only mean that that factor is negligible in the determination of distribution. Michael (1911, p. 139) found that *Sagitta bipunctata* is always most frequent and abundant at salinities between 33.605 and 33.648. There is no reason to expect that such a relation between abundance and salinity, in regard to consistent results at least, should be absent in the case of *Calanus* if salinity is a factor in distribution. It is of course possible that a relation between abundance and salinity would be established if a larger number of hauls were available, but as far as our data go at present we are hardly justified in claiming that there is such a relation. The animals are known to be mostly a long distance below the surface from 8 a.m. to 4 p.m., and the relation between abundance and salinity during those hours (as shown in table 19, section B), concerns a relatively small proportion of the population. When they are most abundant at the surface (4 p.m.–4 a.m.) the abundance is greatest at this salinity at one time and at that at another (table 19, sections C and D). On the whole, we are not warranted at present in forming a definite conclusion as to the effect of salinity on distribution.

Farran (1910, p. 83) has recently summarized the facts as to the distribution of *Calanus finmarchicus,* including under that name the species known as *helgolandicus* and *septentrionalis.* The form is designated as eurythermal and stenohaline, the temperature limits (p. 87) being from 16° at the surface to 13° at the bottom in the mouth of the English Channel; in the north it is found in waters of 0° or less. Cleve gives the temperature limits in the North Atlantic as 22° C to 0°2 C. (Farran 1910, p. 87). Farran states (p. 88) that the organisms

are found only in waters where the salinity is between 35:30 and 33:00. If that is true for this region also, we are not likely to find a correlation between salinity and abundance, since the salinities appear to be always within the limits mentioned by Farran.

Distribution of *Eucalanus elongatus*

The distribution of this copepod has been dealt with briefly in an earlier paper (Esterly, 1911a), but it seems desirable to make use of the larger number of hauls available now. In table 21, which follows, the occurrence at the surface is shown, the day being divided into twelve two-hour periods.

TABLE 21

Distribution of *Eucalanus elongatus* at the surface in two-hour periods

	Time of day	No. of hauls		No. of hours		No. of animals		Frequency	
		Total	Success.	Total	Success.	Total	Per hour	Haul	Time
	a.m.	A	B	C	D	E	F	G	H
1.	6–8	35	9	27.2	6.8	106	3.9	33	25
2.	8–10	21	2	20.2	1.3	24	1.2	9	6
3.	10–12	14	6	9.8	3.3	112	11.0	43	34
	p.m.								
4.	12–2	14	3	9.0	1.8	22	2.4	21	20
5.	2–4	14	2	9.7	0.6	263	27.1	6	14
6.	4–6	13	1	9.9	1.0	1	0.1	10	8
7.	6–8	30	8	19.9	3.3	403	20.2	26	16
8.	8–10	8	5	4.4	2.6	321	73.0	62	60
9.	10–12	1	0	2.8	0	0	0	0	0
	a.m.								
10.	12–2	3	1	2.6	0.87	6	2.3	38	33
11.	2–4	8	4	12.0	3.3	119	16.0	28	50
12.	4–6	41	14	26.6	8.3	1050	40.0	34	31

TABLE 22

Summary of table 21

1.	Total number of hauls	111	92.
2.	Number of successful hauls	23.0	33.0
3.	Total number of hours	85.8	68.3
4.	Number of successful hours	15.7	18.3
5.	Total number of animals	528	1899.
6.	Average per hour	6.2	27.8
7.	Haul frequency	21	36.
8.	Time frequency	18	27.

Inspection of table 22 will show that *Eucalanus* is both more abundant (lines 5 and 6) and more frequent (lines 7 and 8) by night than by day. In table 21 it is shown that the highest hourly average (column F) is obtained from about the middle to the end of evening twilight (line 8); the frequencies are also highest at that time (columns G and H). The curve of hourly averages at the surface for *Eucalanus* is in figure 2.

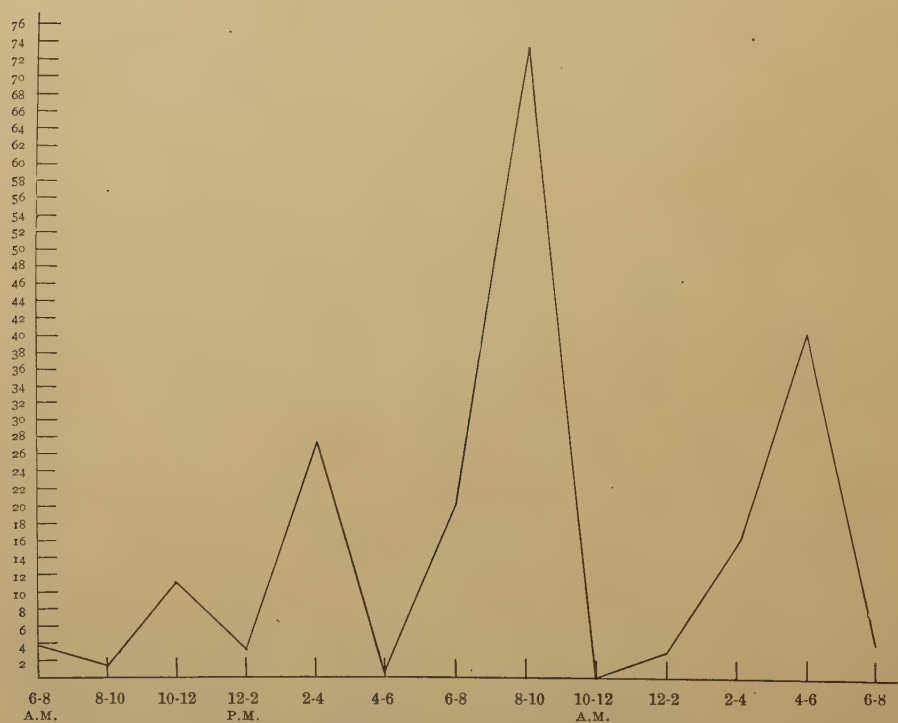

Fig. 2. *Eucalanus elongatus.* Variations in numbers per hour at the surface according to time of day. Data in table 21.

The occurrence of *Eucalanus* is much more irregular at the surface than that of *Calanus,* as can be seen by comparing the curves of the two species (figs. 1 and 2). It is also noticeable that the former species was taken in a much smaller proportion of hauls than the latter (cf. lines 7 and 8 in table 22 with those in table 13). Notwithstanding this, both species occur

most abundantly at the surface within the same four hours of the evening.

It is difficult to say whether the irregular occurrence of *Eucalanus* at the surface is due to lack of hauling at certain times or to the habit of the species. There is no reason to feel that the curve for *Eucalanus* must resemble that for *Calanus*, yet it might if more hauls were available. The afternoon, evening and morning maxima shown in figure 2 are probably of normal occurrence; they should be so considered at this time, at any rate.

The distribution of *Eucalanus* as shown by the horizontal closing nets will not be considered here, since that was done in another paper (Esterly, 1911a). There appears to be an extensive movement of the species below the surface, but it can hardly be called an upward migration such as is so evident for *Calanus*. The daylight plurimum of *Eucalanus* as shown by the horizontal nets is at 200 fathoms.

The occurrence of *Eucalanus* as shown by hauls with the vertical closing nets is given in table 23 which follows. It is similar to table 14 for *Calanus*.

TABLE 23

Distribution of *Eucalanus* as shown by the vertical closing nets

		Day 6-12 a.m., 4-6 p.m.					Night 2-6 a.m., 6-8 p.m. (below 50 f.)				
	Depth in fathoms	Hauls Total	Hauls Success.	Animals Total	Animals Per fath.	Freq.	Hauls Total	Hauls Success.	Animals Total	Animals Per fath.	Freq.
1.	5–0	15	0	0	0.0	0	14	4	6	1.2	29
2.	10–5	15	3	11	2.0	20	14	8	11	2.2	52
3.	15–10	15	4	5	1.0	27	15	9	19	3.7	60
4.	20–15	15	5	18	3.6	33	15	12	21	4.2	80
5.	25–20	15	10	32	6.4	66	14	11	44	8.8	78
6.	30–25	17	11	46	9.3	65	14	13	30	6.0	93
7.	40–30	14	10	38	3.8	72	14	12	42	4.2	81
8.	50–40	16	12	52	2.6	66	15	13	65	6.5	82
9.	75–50	17	12	84	3.3	70	16	12	48	1.9	66
10.	100–75	6	4	10	0.4	66	3	1	4	0.16	33
11.	150–100	6	5	62	1.2	83	4	3	79	1.6	75
12.	200–150	6	6	398	8.0	100	3	3	20	0.4	100
13.	250–200	6	6	616	12.0	100	1	1	1	0.02	100
14.	300–250	4	3	286	5.7	75	1	1	1	0.02	100

TABLE 24

Summary of table 23

	Specimens per fathom		Total hauls		Successful hauls		Frequency	
	Day	Night	Day	Night	Day	Night	Day	Night
Between 0 and 50 fathoms	40.0	48.0	122	115	53	83	43	72
Between 50 and 250 fathoms	5.8	.8	41	27	33	20	80	74

We may gather from table 23 that the daylight plurimum is near 200 fathoms (lines 12 and 13) as was shown by the Kofoid net as well (Esterly 1911b). Though there is a plurimum at 30–25 fathoms nearly as large as that at 200 fathoms, the frequency for the former depth is 65, while for the latter it is 100. This probably means that the larger proportion of the animals is at 200 fathoms or thereabouts.

In table 24 it is plain that these animals are more abundant and more frequent above 50 fathoms by night than by day. The number per fathom at night below 50 fathoms is only about one-seventh of that during the day, and the night frequency is smaller. Since the vertical and horizontal nets both show that the hourly averages are smaller in deep water by day than by night, and since the surface net takes more at night, we are justified in assuming that the organisms move upward at night. There is no such clean-cut evidence of daily oscillation as was obtained for *Calanus* and, while more hauling might show such a condition for *Eucalanus,* there is no more reason at present for attributing its manner of distribution to the methods of collecting than to the organisms themselves.

Distribution with regard to temperature.—As in the case of *Calanus,* we are limited to surface hauls for evidence as to the effect of temperature on the distribution of *Eucalanus.* The species was obtained in 31 hauls out of the 130 for which the temperature is known. Table 25 is intended to show the distribution as regards temperature.

TABLE 25

Distribution of *Eucalanus* at surface with regard to temperature

	Temperature	No. of hauls Total 1	No. of hauls Success. 2	No. of hours Total 3	No. of hours Success. 4	No. of animals Total 5	No. of animals Per hour 6	Frequency Haul 7	Frequency Time 8
	A. 4-8 a.m.								
1.	16°0–17°0	16	3	11.0	1.2	5	0.45	19	9
2.	17°1–18°0	15	2	14.0	4.0	44	3.1	13	21
3.	18°1–19°0	10	1	6.4	0.35	6	0.93	10	5
4.	19°1–21°5	14	5	6.8	1.6	45	6.6	51	23
	B. 8 a.m.-4 p.m.								
1.	16°0–17°0	10	0	0	0	0	0	0	0
2.	17°1–18°0	8	2	4.5	0.66	16	3.5	25	14
3.	18°1–19°0	6	0	3.2	0	0	0	0	0
4.	19°1–21°5	7	2	6.8	1.0	15	2.2	28	15
	C. 4-10 p.m.								
1.	16°0–17°0	1	1	0.42	0.42	81	194.0	100	100
2.	17°1–18°0	6	3	5.6	4.4	3	0.5	50	79
3.	18°1–19°0	9	0	7.5	0	0	0	0	0
4.	19°1–21°5	17	7	8.3	4.1	372	44.8	41	49
	D. 10 p.m.-4 a.m.								
1.	16°0–17°0	4	3	3.4	2.5	56	16.5	75	74
2.	17°1–18°0	3	1	2.9	0.58	57	19.6	33	20
3.	18°1–19°0	3	0	5.0	0	0	0	0	0
4.	19°1–21°5	1	0	1.0	0	0	0	0	0

The only conclusion that is justifiable from the above data is that the distribution of *Eucalanus* is unrelated to the surface temperature. For example, the highest average per hour in section A is at a temperature from 19°1 to 21°5; in section B the high average is obtained when the temperature varies from 17°1 to 18° In other words, we find that the relation between temperature and abundance varies with the time of day. This should be taken to mean, in my opinion, that whatever the effective factor is in determining distribution, temperatures within the limits observed at the surface are practically negligible. It may be pointed out as a matter of interest that only one haul out of twenty-eight took *Eucalanus* when the temperature was 18°1–19° (table 25, line 3 of all the sections).

It may be that the animals really are less abundant at those temperatures than at the others as a rule, but we have hardly enough data for more than a suggestion to that effect.

The effect of salinity on the distribution of *Eucalanus* at the surface can be determined from only 14 hauls. More than half of these hauls were made between 4 and 10 p.m., this being the time when the animals are most abundant at the surface anyway. This small number of hauls does not show that there is any connection between the salinity of the water and abundance; the limits are 33.534 and 34.069. A larger number of collections ought to be available if we are to have a reasonable basis for any conclusion. Farran (1910, p. 93) gives a summary of the occurrence and distribution of *Eucalanus* as derived from the records of the International Council.

Distribution of *Metridia lucens*

This species is the third most abundant in the San Diego region. It was taken in a much smaller number of hauls than *Calanus* or *Eucalanus,* but certain facts about its distribution seem clear. The distribution of this species at the surface is shown in table 26, which follows.

TABLE 26

Distribution of *Metridia lucens* at the surface in two-hour periods

	Time of day a.m.	No. of hauls Total A	Success. B	No. of hours Total C	Success. D	No. of animals Total E	Per hour F	Frequency Haul G	Time H
1.	6–8	35	1	27.2	0.62	42	1.5	3	2
2.	8–10	21	2	20.2	2.3	2	0.1	9.6	11
3.	10–12	14	0	9.8	0.0	0	0.0	0	0
	p.m.								
4.	12–2	14	0	9.0	0.0	0	0.0	0	0
5.	2–4	14	0	11.1	0.0	0	0.0	0	0
6.	4–6	13	1	9.9	0.6	6	0.7	8	6
7.	6–8	30	1	20.0	0.7	1	0.05	3	3
8.	8–10	8	4	4.4	2.4	228	52.0	50	55
9.	10–12	1	1	2.8	2.8	31900	11380.0	100	100
	a.m.								
10.	12–2	3	3	2.6	2.6	3401	1310.0	100	100
11.	2–4	8	6	12.0	9.4	2124	177.0	75	78
12.	4–6	41	9	26.6	6.2	486	17.6	22	22

TABLE 27

Summary of table 26

		Day	Night
1.	Total number of hauls	111.	92.
2.	Number of successful hauls	4	24
3.	Total number of hours	85.8	68.3
4.	Number of successful hours	3.5	24.1
5.	Total number of animals	50.	38140
6.	Average per hour	0.6	573
7.	Haul frequency	6	25
8.	Time frequency	6	33

Table 26, columns E and F, lines 9 and 10, shows that *Metridia* is overwhelmingly more abundant and frequent on the surface between 10 p.m. and 2 a.m.; a noticeable increase is observable from 8 to 10 p.m. (line 9). The time of great abundance for this species at the surface corresponds with that for *Calanus* and *Eucalanus*. Beginning with line 7 in table 26 and following columns E, F, G and H through to line 12, it is noticeable that the numbers of animals and the frequencies increase to the amounts in line 9; after that the numbers decrease gradually to line 12, and the frequencies also, following line 10. The organisms are practically absent from the surface between 8 a.m. and 8 p.m. (lines 3–7). While this evidence of a diurnal migration is based on a comparatively small number of hauls, it is so clear that we can hardly doubt its reliability. Figure 3 shows the varying numbers per hour at the surface in a curve which is made up from the data in table 26.

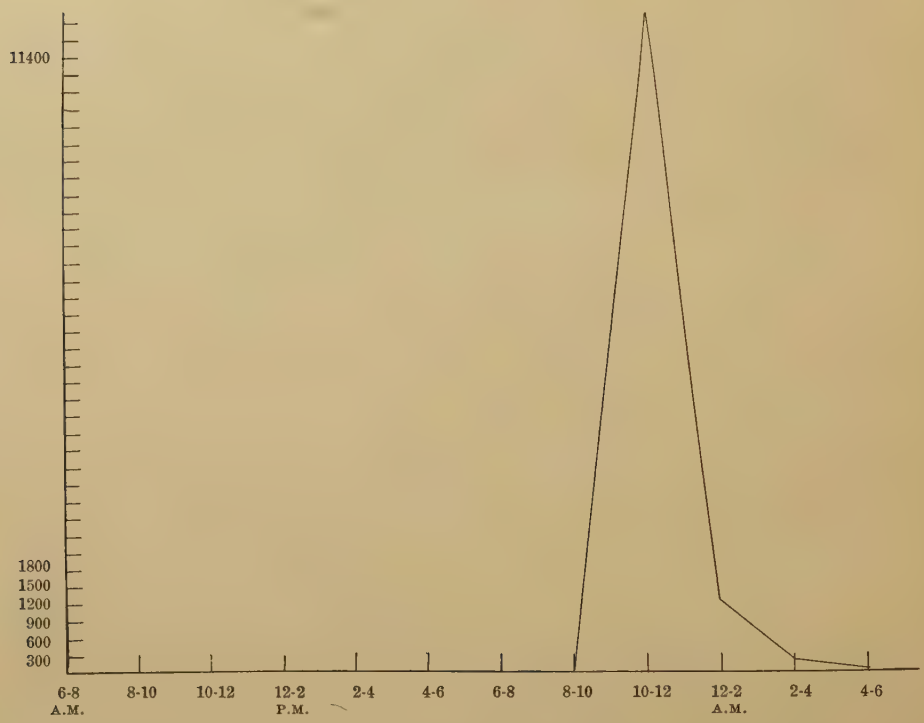

Fig. 3. *Metridia lucens.* Variations in numbers per hour at surface according to time of day. Data in table 26; as may be seen there, the numbers before 8 a.m. are so small that they do not appear on a plot of this scale.

In table 28 which follows, the data for 144 hauls with the horizontal closing nets are arranged to show the occurrence of *Metridia* at various depths at different times.

TABLE 28

Distribution of *Metridia* as shown by the horizontal closing nets

A. 6 a.m.–6 p.m.

Depth in fathoms	No. of hauls Total	Success.	No. of hours Total	Success.	No. of animals Total	Per hour	Frequency Haul	Time
	1	2	3	4	5	6	7	8
1. 4–6	5	0	1.6	0	0	0	0	0
2. 7–12	6	0	2.5	0	0	0	0	0
3. 15–20	8	2	2.1	.47	15	7.1	25	22
4. 25–35	10	0	2.6	0	0	0	0	0
5. 50–75	12	1	3.3	.13	3	.9	8	4
6. 100–160	8	2	2.7	.82	28	10.3	25	30
7. 200–250	9	3	3.2	.82	7	2.2	33	26
8. 300–550	7	2	3.3	.57	3	.9	29	29

TABLE 28 (*Continued*)

B. 6–10 p.m.

Depth in fathoms	No. of hauls Total 1	Success. 2	No. of hours Total 3	Success. 4	No. of animals Total 5	Per hour 6	Frequency Haul 7	Time 8
1. 4–6	3	1	.92	.17	5	.54	33	18
2. 7–12	4	2	1.8	.58	46	39.	50	32
3. 15–20	2	0	.5	0	0	0	0	0
4. 25–35	4	1	1.1	.20	2	.82	25	18
5. 50–75	5	2	1.9	.7	38	19.	40	37
6. 100–160	7	3	2.4	.82	19	7.9	43	38
7. 200–250	3	0	1.6	0	0	0	0	0
C. 10 p.m.–2 a.m.								
1. 4–6	1	1	.17	.17	219	1314.	100	100
2. 7–12	1	1	.18	.18	284	1550.	100	100
3. 15–20	1	1	.17	.17	3	18.	100	100
4. 25–35	1	1	.25	.25	1	4.	100	100
D. 2–6 a.m.								
1. 4–6	2	0	.6	0	0	0	0	0
2. 7–12	2	0	.5	0	0	0	0	0
3. 15–20	3	0	.7	0	0	0	0	0
4. 25–35	3	2	.8	.24	5	25.	66	33
5. 50–75	3	1	1.	.4	2	2.	33	40
6. 100–160	4	2	1.6	.5	60	37.	50	31

In table 29, which follows, there is a summary of table 28 by sections. It seems evident enough that there is a diurnal migration of *Metridia* if the number of hauls may be considered large enough to give a reliable basis for a conclusion.

TABLE 29

Summary of Table 28

	Section A 6 a.m.-6 p.m.	Section B 6-10 p.m.	Section C 10 p.m.-2 a.m.	Section D 2-6 a.m.
Total number of animals	56	110	507.	67
Average per hour for entire time	2.6	10.1	659.5	13
Highest average per hour	10.3	39.	1550	37
Depth of highest hourly average	100–160 f.	7–12 f.	10 f.	100–160 f.
Time frequency	13	24	100	22

The frequency, total number of animals and highest average per hour reach the minimum in Section A, that is, during daylight. It should be noted that the plurimum, according to these hauls, is at a depth of from 100 to 160 fathoms.

Section D is next to section A in all respects, and the depth at which the plurimum is located is within the same limits as for daylight hours.

Section B, including hauls made between 6 and 10 p.m., shows a marked rise in frequency with a greatly increased average for the whole time as well as a much greater plurimum. The plurimum was found between 7 and 12 fathoms.

The maximum in all respects is reached between 10 p.m. and 2 a.m. (section C), with the plurimum at 10 fathoms.

While it may be argued that the number of hauls is so small as to render it inadvisable to draw conclusions from the horizontal closing nets, the evidence for diurnal movements is so marked in tables 28 and 29 that one can hardly doubt that they actually take place. It is noticeable that the main results set forth in tables 28 and 29 check closely with those in tables 26 and 27 for the surface collections.

The results of hauling with the vertical closing nets are given in table 30, which follows.

TABLE 30

Distribution of *Metridia* as shown by the vertical closing nets

		Day					Night				
		6-12 a.m., 4-6 p.m.					2-6 a.m., 6-8 p.m. (below 50 f.)				
	Depth in fathoms	No. of hauls		No. of animals			No. of hauls		No. of animals		
		Total	Success.	Total	Per fath.	Freq.	Total	Success.	Total	Per fath.	Freq.
		A	B	C	D	E	F	G	H	I	J
1.	5–0	15	1	2	0.4	7	14	1	2	0.2	7
2.	10–5	15	0	0	0.0	0	14	1	4	0.8	7
3.	15–10	15	0	0	0.0	0	15	3	22	4.4	25
4.	20–15	15	0	0	0.0	0	15	4	50	10.0	27
5.	25–20	15	0	0	0.0	0	14	5	81	16.2	36
6.	30–25	17	0	0	0.0	0	14	6	134	26.8	43
7.	40–30	14	0	0	0.0	0	14	6	110	11.0	43
8.	50–40	16	2	2	2.0	12	15	7	101	10.1	47
9.	75–50	17	6	485	19.4	35	16	11	175	7.0	69
10.	100–75	6	2	201	8.0	33	3	1	1036	41.1	33
11.	150–100	6	4	251	5.0	66	4	3	500	10.0	75
12.	200–150	6	6	1467	29.3	100	3	2	34	0.7	66
13.	250–200	6	6	828	16.5	100	1	0	0	0.0	0
14.	300–250	4	3	489	9.8	75	1	0	0	0.0	0

TABLE 31

Summary of table 30

	Specimens per fathom		Total hauls		Success. hauls		Frequency	
	Day	Night	Day	Night	Day	Night	Day	Night
Between 0 and 40 fathoms	0.5	10.1	106	100	1	26	0.9	26
Between 40 and 200 fathoms	23.2	13.1	51	41	20	24	40	58

The almost total absence of *Metridia* during the day above 40 fathoms is evident (table 30, columns A–E, lines 1–7). The daylight plurimum is at 200–150 fathoms, which checks roughly with the results from the horizontal nets (table 28, section A, column 6, line 6). As in the other species, a detailed comparison of vertical with horizontal closing nets is not possible because of the different times at which collecting was done in the two cases.

It is plain, however, from table 31 that *Metridia* is much more abundant by night than by day above 40 fathoms, and also more frequent; and that between 40 and 200 fathoms it is more abundant but not so frequent by day. These facts suggest that there is an upward migration at night, which was indicated from hauls with the surface and horizontal closing nets. A puzzling question arises in connection with table 31 as to why the catches by day below 40 fathoms should be larger than those at night though there are more successful hauls at night. There is no evidence available now to show why that condition should prevail. It is possibly due to the times at which the vertical closing hauls were made, but such results were not obtained in the case of *Calanus* (table 15) or of *Eucalanus* (table 23). In the case of *Metridia* the night collections below 40 fathoms are larger than the day collections above that level (table 31), but this does not hold for the other two species. These considerations suggest that we have to deal with a peculiarity of the species in table 31, but the matter should be left open until more collections are at hand.

There seems to be little room for doubt that *Metridia* as a whole is a good deal more abundant at night in the upper water than it is by day.

The hauls are so few (fifteen) for which temperatures are known where *Metridia* was taken, that it is useless to try to draw conclusions as to the effect of those factors in the distribution of the species. It may be stated, however, that it occurred at the surface when the temperatures ranged from 14°.7 to 20°.5, and at salinites from 33.577 to 33.856. As is the case with the two preceding species, I find it impossible to separate the temperature and light effects. The abundance varied from nearly 12,000 per hour at 19° between the hours of 10 and 12 p.m., to 8 per hour at a temperature of 19°.2 between 4 and 6 a.m. Hauls 1875 to 1892 inclusive in table 3 form an interesting group if it is desired to note how abundance varies with the time of day while the temperature is practically stationary, there being a range of only 0°.3.

Farran (1910, p. 67) gives the vertical range of *Metridia lucens* as from 0 to over 2000 meters, and mentions the marked tendency to swarm at night at the surface. The region of greatest abundance during the day is between 50 and 100 meters (about 27–55 fathoms). This is far above the depth of the daylight plurimum for this species according to our results. The difference is probably due to the different depth to which light penetrates in this region as compared with that covered by the International Council (see Hjort, 1910, p. 505, and the discussion at the end of this paper).

The other species found at the surface are listed in table 32 which gives their ranges in fathoms. Each of the ten species was more or less abundant at the surface, and since they are the less common ones they form a group which may conveniently be considered alone. The depths given for the vertical closing nets are upper and lower possible limits; the open vertical net did not take specimens in hauls that began *above* the indicated depths.

TABLE 32

		Horiz. closing	Vertical closing Range in fathoms	Open vertical
1.	*Euchirella pulchra*	5–350	40–250	150
2.	*Euchirella rostrata*	5–200	30–50	40
3.	*Gaidius pungens*	50–350	25–350	150
4.	*Labidocera trispinosa*	.....	0–75	15
5.	*Pleuromamma abdominalis*	5–250	20–300	20
6.	*Pleuromamma gracilis*	7.5	10–250	....
7.	*Pleuromamma quadrungulata*	5–350	100–300	150
8.	*Rhincalanus nasutus*	15–350	15–300	60
9.	*Scolecithrix persecans*	25–300	50–300	150
10.	*Undeuchaeta bispinosa*	5–350	20–300	100

The depths indicated for the horizontal closing nets are the more reliable, though it is noticeable that in several cases the range obtained from hauls with the vertical closing nets agrees closely with the other. In the case of *Euchirella rostrata,* for example, the lower limit at which the animals were taken with the vertical nets is far above that with the horizontal nets. Both sorts of nets agree, however, in showing that most of the species are wide-ranging.

Labidocera trispinosa.—This copepod was fourth in order of abundance at the surface and was taken in fairly large numbers in 28 hauls. Table 33 and figure 4 show the manner in which the animals occurred in relation to the time of day.

TABLE 33

Distribution of *Labidocera* at the surface in two-hour periods

	Time of day	No. of hauls Total	Success.	No. of hours Total	Success.	No. of animals Total	Per hour	Frequency Haul	Time
	a.m.	A	B	C	D	E	F	G	H
1.	6–8	35	3	27.2	1.8	6	0.2	8	4
2.	8–10	21	3	20.2	3.6	234	11.7	14	17
3.	10–12	14	1	9.8	1.2	2	0.2	7	12
	p.m.								
4.	12–2	14	0	9.0	0.0	0	0.0	0	0
5.	2–4	14	1	11.1	0.5	1	0.9	7	4
6.	4–6	13	3	9.9	2.5	13	1.2	23	25
7.	6–8	30	5	20.0	3.8	2630	131.1	16	19
8.	8–10	8	2	4.4	1.1	3	0.6	25	23
9.	10–12	1	0	2.8	0.0	0	0.0	0	0
	a.m.								
10.	12–2	3	0	2.6	0.0	0	0.0	0	0
11.	2–4	8	3	12.0	2.4	52	4.3	37	20
12.	4–6	41	7	26.6	4.4	527	21.2	17	16

TABLE 34

Summary of table 33

		Day	Night
1.	Total number of hauls	111	92
2.	Number of successful hauls	11	17
3.	Total number of hours	85.8	68.3
4.	Number of successful hours	9.6	15.7
5.	Total number of animals	256	3212
6.	Average per hour	3.0	470.2
7.	Haul frequency	10	18
8.	Time frequency	11	23

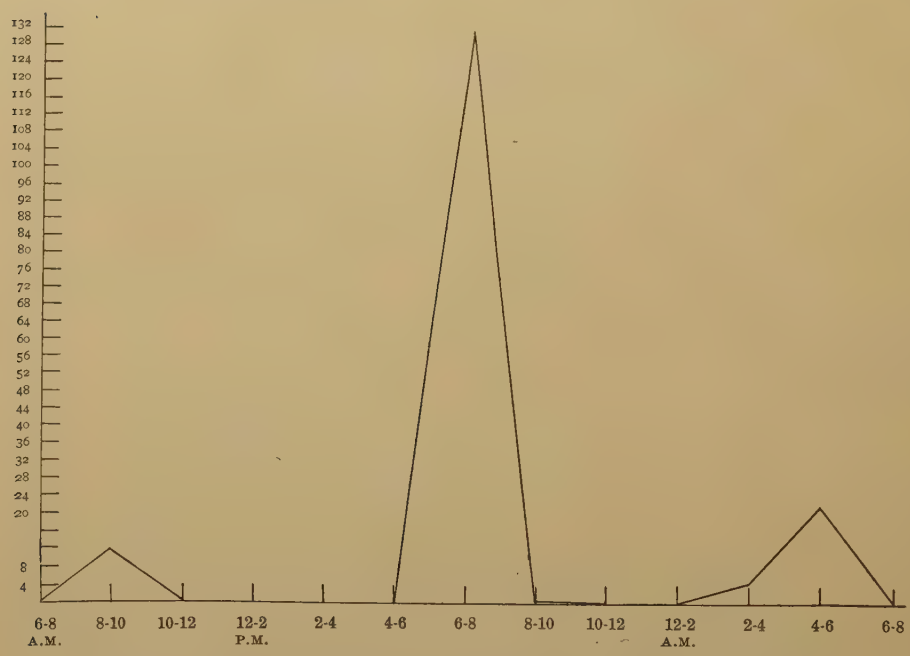

Fig. 4. *Labidocera trispinosa.* Variations in numbers per hour at the surface according to the time of day. Data in table 33.

The preponderance at night at the surface is marked (lines 5 and 6 of table 34). The night frequency is also somewhat greater (lines 7 and 8). The plurimum is reached between 6 and 8 p.m. (table 33, columns E and F, line 7), but the

frequencies are not so high then as at other times. The low frequencies throughout table 33 give some idea of the rarity of *Labidocera* at the surface, and on the whole the results of surface hauling are rather obscure except in the matters just pointed out.

Labidocera appears to be found only above 100 fathoms; it was not obtained in vertical closing hauls below 75 fathoms. There were 11 of these hauls and 21 animals were obtained, the majority (16) at night. In the absence of any successful hauls with the horizontal closing nets, it is difficult to say where the day plurimum is located; it is barely indicated by the vertical nets as between the surface and 5 fathoms.

The lowest and highest surface temperatures and salinities for *Labidocera* were, respectively, 13°1 and 22°3, and 33.563 and 33.704.

Euchirella pulchra was obtained at the surface in seven hauls which captured 17 animals. One day haul took one animal; the other 16 animals were obtained in six night hauls. The lowest temperature at the surface when this species was taken was 13°8, the highest 19°9; the lowest and highest salinities were, respectively, 33.536 and 33.648. Figure 5 shows the time of greatest abundance at the surface; the numbers of animals given in the figure are reckoned on the basis of one-hour hauls and then increased ten times.

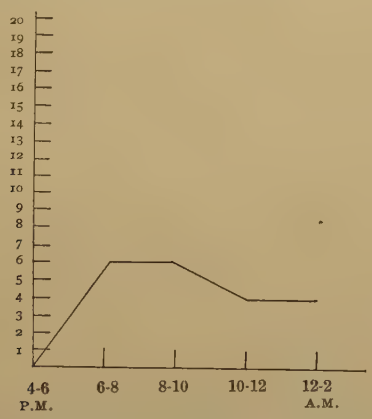

Fig. 5. *Euchirella pulchra.* Variations in numbers per ten hours of hauling at the surface during the night.

The distribution of this species as shown by the closing nets is indicated in tables 35 and 36 which follow. It is evident from both tables that the animals are most abundant during the day in deep water (table 35, column E, lines 3 and 4; table 36, column D, lines 3 and 4). Neither the horizontal nor vertical nets took the animals above 100 fathoms during the day, though some were taken there during the night. If allowance is made for differences in the action of the two sorts of nets, inspection of the tables under consideration shows that the organisms leave the deep water during the night and are found at much higher levels by night than by day. So far as this evidence goes, it indicates that there is an upward movement at night.

TABLE 35

Distribution of *Euchirella pulchra* as shown by hauls with the horizontal closing nets, day and night hauls compared

	Depth	A Total hauls		B Successful hauls		C Total hours		D Total animals		E Animals per 10-hr. haul		F Haul frequency	
		Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
1.	4–35	29	27	0	2	8.8	7.8	0	4	0	5	0	7
2.	50–75	12	8	0	0	3.3	3.0	0	0	0	0	0	0
3.	100–160	8	11	2	1	2.7	4.0	12	2	41	5	25	9
4.	200–250	9	3	3	0	3.2	1.6	13	0	40	0	33	0
5.	300–350	7	0	2	0	3.3	0.0	2	0	6	0	28	0

TABLE 36

Distribution of *Euchirella pulchra* as shown by hauls with the vertical closing nets, day and night hauls compared

	Depth	A Total hauls		B Successful hauls		C Total animals		D Animals per 100-f. haul		E Haul frequency	
		Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
1.	40–0	106	100	0	0	0	0	0	0	0	0
2.	100–40	39	34	0	2	0	13	0	21	0	6
3.	200–100	12	7	3	1	12	8	12	8	25	14
4.	250–200	6	1	6	0	47	0	94	0	100	0
5.	200–250	4	1	3	0	24	0	48	0	75	0

Euchirella rostrata.—Nineteen specimens were obtained in 13 surface hauls. The number in night hauls (16) is five times as great as that in day hauls (3), and there are three times as many successful night as day hauls. The lowest and highest temperatures and salinities for the surface hauls taking the species are, respectively, 16°.9 and 20°.9, and 35.534 and 33.670.

The center of migration (daylight plurimum) seems to be at about 200 fathoms, yet out of 8 hauls during the day at or below 100 fathoms, with the closing nets only one was successful, taking one animal; the other seven specimens were obtained above 100 fathoms, one by day and six by night, the latter being taken in six hauls. Evidently, the species moves upward at night if the numbers taken at the surface then as compared with those during the day can be taken as representative of the whole population.

Gaidius pungens.—This species is one of the commonest in the hauls with closing nets, but extremely rare at the surface. It was taken there in only three hauls, all of which were in daylight. It was obtained in 12 hauls with the horizontal closing nets and in 26 with the vertical nets; these took 148 and 777 specimens respectively. The distribution of these specimens at different depths and at various times as shown by the horizontal closing nets is indicated in table 37 which follows.

TABLE 37

Distribution of *Gaidius pungens* as shown by hauls with the horizontal closing nets, day and night hauls compared

	Depth	A Total hauls		B Successful hauls		C Total hours		D Total animals		E Animals per 10-hr. haul		F Haul frequency	
		Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
1.	4–35	29	27	0	0	8.8	7.8	0	0	0	0	0	0
2.	50–75	12	8	1	1	3.3	3.0	1	2	3	6	8	12
3.	100–160	8	11	2	2	2.7	4.0	55	4	203	14	25	18
4.	200–250	9	3	5	0	3.2	1.6	81	0	506	0	55	0
5.	300–550	7	0	1	0	3.3	0.0	75	0	18	0	14	0

The region of greatest abundance is plainly between 200 and 250 fathoms during the day. This level is deserted at night, when the region of greatest abundance is between 100

and 160 fathoms. Specimens were taken both by day and by night between 50 and 75 fathoms, but the abundance and frequency are both greater at night. The table gives, on the whole, some evidence of an upward movement at night.

The vertical distribution of *Gaidius* as shown by hauls with the vertical closing nets appears in table 38 which follows. The evidence is similar to that in the preceding table, though much clearer as to the upward movement at night. The animals were not obtained above 100 fathoms except at night, nor below 200 fathoms except during the day; this evidently points to a movement toward the upper levels during the night.

TABLE 38

Distribution of *Gaidius pungens* as shown by hauls with the vertical closing nets, day and night hauls compared

	Depth	A Total hauls		B Successful hauls		C Total animals		D Animals per 100-f. haul		E Haul frequency	
		Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
1.	40–0	106	100	0	4	0	9	0	22	0	4
2.	100–40	39	34	0	2	0	3	0	50	0	6
3.	200–100	12	7	5	6	55	58	55	58	41	85
4.	250–200	6	1	6	0	316	0	632	0	100	0
5.	300–250	4	1	3	0	345	0	690	0	75	0

Pleuromamma abdominalis.—As may be seen in table 11, this species was fairly abundant at the surface, ranking fifth in that respect. Two hauls at the surface during the day were successful, taking two animals; the discussion of surface distribution may therefore be limited to night hauls. Table 39 is arranged like a number that have preceded, but deals only with night hauls that obtained *P. abdominalis* at the surface. Figure 6 is derived from the data in table 39.

TABLE 39

Distribution of *Pleuromamma abdominalis* at the surface at night in two-hour periods

	Time of day p.m.	No. of hauls Total A	Success. B	No. of hours Total C	Success. D	No. of animals Total E	Per hour F	Frequency Haul G	Hour H
1.	6–8	30	2	20.0	2.4	45	2.2	7	12
2.	8–10	8	4	4.4	2.2	254	58.8	50	50
3.	10–12	1	1	2.8	2.8	14	5.0	100	100
	a.m.								
4.	12–2	3	3	2.6	2.6	39	15.0	100	100
5.	2–4	8	3	12.0	3.0	12	1.0	37	25
6.	4–6	41	4	26.6	1.4	6	0.22	10	5

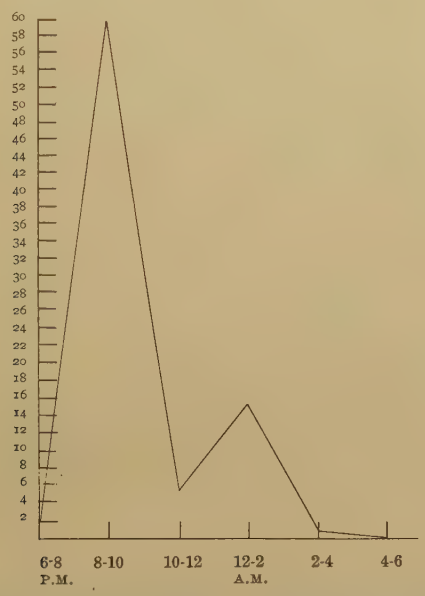

Fig. 6. *Pleuromamma abdominalis.* Variations in numbers per hour at the surface at night. Data in table 39.

The time of greatest abundance is from 8–10 p.m. (line 2), though the frequencies are greatest within the next four hours (lines 3 and 4). It seems that there is a sudden and marked rise to the maximum and a drop that is almost as abrupt. This species was found at the surface at temperatures ranging from

13°8 to 20°5, and at salinities from 33.539 to 33.762. As in the case of other species, it is not possible here to separate the possible effects of temperature from the more evident effect of light.

The hauls in which *P. abdominalis* was taken with the horizontal closing nets are summarized in table 40 which follows. It is scarcely necessary to point out the greater abundance between 4 and 35 fathoms (line 1) at night, or the smaller numbers taken at night as compared with the day catches between 100 and 160 fathoms (line 3).

TABLE 40

Distribution of *Pleuromamma abdominalis* as shown by hauls with the horizontal closing nets, day and night hauls compared

	Depth	A Total hauls		B Successful hauls		C Total hours		D Total animals		E Animals per 10-hr. haul		F Haul frequency	
		Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
1.	4–35	29	27	0	3	8.8	7.8	0	45	0	57	0	11
2.	50–75	12	8	1	1	3.3	3.0	1	1	3	3	8	12
3.	100–160	8	11	2	3	2.7	4.0	17	10	60	25	25	27
4.	100–250	9	3	2	1	3.2	1.6	34	1	10	6	22	33
5.	300–550	7	0	1	0	3.3	0.0	1	0	3	0	14	0

The collections with the vertical closing nets (table 41) show that there is apparently an upward movement at night. The region of greatest abundance is below 200 fathoms (lines 4 and 5) during the day, but this region is deserted at night. The animals were not taken above 100 fathoms except at night.

TABLE 41

Distribution of *Pleuromamma abdominalis* as shown by hauls with the vertical closing nets, day and night hauls compared

	Depth	A Total hauls		B Successful hauls		C Total animals		D Animals per 100-f. haul		E Haul frequency	
		Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
1.	40–0	106	100	0	4	0	4	0	10	0	4
2.	100–40	39	34	0	4	0	5	0	8	0	11
3.	200–100	12	7	7	4	27	7	27	7	58	57
4.	250–200	6	1	6	0	29	0	58	0	100	0
5.	300–250	4	1	3	0	28	0	56	0	75	0

Pleuromamma gracilis.—This species was taken in seven surface hauls, all of which were at night and took 213 animals. The largest number of animals was 165 between 8 and 10 p.m. The horizontal closing nets took *P. gracilis* but once, a haul between 6 and 8 p.m. at 7.5 fathoms containing one animal. Six hauls with the vertical closing nets obtained 316 animals. One of these (no. 2053) contained 253 specimens; this haul was from 200 to 150 fathoms in the middle of the afternoon. None of the animals was taken above 150 fathoms with the closing nets except at night, and the center of migration may be taken as 150 fathoms.

The lowest and highest surface temperatures at which *P. gracilis* was taken are 13°.8 and 20°.2 respectively; the salinities range from 33.578 to 33.603.

This species was taken in only one haul with the horizontal closing net. The results of collections with the vertical nets are shown in table 42. The center of migration is at 100–200 fathoms (line 3), but there is little evidence of an upward migration except in the fact that that region is deserted at night.

TABLE 42

Distribution of *Pleuromamma gracilis* as shown by hauls with the vertical closing nets, day and night hauls compared

	Depth	A Total hauls		B Successful hauls		C Total animals		D Animals per 100-f. haul		E Haul frequency	
		Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
1.	40–0	106	100	0	0	0	0	0	0	0	0
2.	100–40	39	34	0	1	0	1	0	1	0	3
3.	200–100	12	7	4	0	303	0	303	0	33	0
4.	250–200	6	1	1	0	2	0	4	0	16	0
5.	300–250	4	1	0	0	0	0	0	0	0	0

Pleuromamma quadrungulata.—This is a very rare form at the surface, for it was obtained in only two day hauls which contained three animals.

The closing nets obtained the animals in much larger numbers, and both sorts of nets agree in that the day plurimum is at 200–250 fathoms. The results of hauling with the horizontal closing nets are shown in table 43. The region of the day

plurimum is between 200 and 250 fathoms (line 4). This is also the location of the region of greatest abundance at night (column E), but the number of animals is much smaller at night; moreover, the animals were taken above 100 fathoms (line 1) only at night.

TABLE 43

Distribution of *Pleuromamma quadrungulata* as shown by hauls with the horizontal closing nets, day and night hauls compared

	Depth	A Total hauls		B Successful hauls		C Total hours		D Total animals		E Animals per 10-hr. haul		F Haul frequency	
		Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
1.	4–35	29	27	0	3	8.8	7.8	0	6	0	7	0	11
2.	50–75	12	8	0	0	3.3	3.0	0	0	0	0	0	0
3	100–160	8	11	2	1	2.7	4.0	8	4	29	10	25	9
4.	200–250	9	3	5	1	3.2	1.6	28	2	80	12	55	33
5.	300–550	7	0	3	0	3.2	1.6	6	0	18	0	43	0

The vertical closing hauls (table 44) did not take the animals above 100 fathoms (lines 1 and 2), and there is a marked reduction in the numbers taken below 100 fathoms at night as compared with day. This is some indication of an upward migration at night, but it is difficult to say in what degree the scarcity in deep water at night is due to lack of hauling.

TABLE 44

Distribution of *Pleuromamma quadrungulata* as shown by hauls with the vertical closing nets, day and night hauls compared

	Depth	A Total hauls		B Successful hauls		C Total animals		D Animals per 100-f. haul		E Haul frequency	
		Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
1.	40–0	106	100	0	0	0	0	0	0	0	0
2.	100–40	39	34	0	0	0	0	0	0	0	0
3.	200–100	12	7	5	4	27	13	27	13	41	57
4.	250–200	6	1	6	1	154	1	208	2	100	100
5.	300–250	4	1	3	1	75	1	150	2	75	100

Rhincalanus nasutus.—These copepods appeared in eleven surface hauls, of which nine were made during the night and contained 46 animals out of a total of 54. The maximum abundance

and frequency occurred between 8 and 10 p.m., as is shown in figure 7. The temperature and salinities ranged from 13°8 to 20°4, and from 33.539 to 33.704.

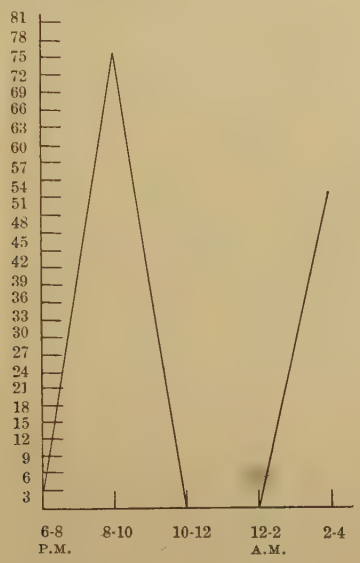

Fig. 7. *Rhincalanus nasutus.* Variations in numbers per ten hours of hauling at the surface at night up to 4 a.m.

The results of hauls made with the horizontal closing nets is shown in table 45. The abundance at 50–75 and at 200–250 fathoms is the same during the day, but the frequency at the latter depth is greater (compare lines 2 and 4); it seems likely, therefore, that the center of migration is located between 200 and 250 fathoms. There is very little evidence of an upward migration at night unless the desertion of the 200–250 fathoms level at night may be so considered.

TABLE 45

Distribution of *Rhincalanus nasutus* as shown by hauls with the horizontal closing nets, day and night hauls compared

	Depth	A Total hauls		B Successful hauls		C Total hours		D Total animals		E Animals per 10-hr. haul		F Haul frequency	
		Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
1.	4–35	29	27	1	1	8.8	7.8	1	1	1	1	3	3
2.	50–75	12	8	1	0	3.3	3.0	2	0	6	0	8	0
3.	100–160	8	11	1	1	2.7	4.0	1	1	3	2	12	9
4.	200–250	9	3	2	0	3.2	1.6	2	0	6	0	22	0
5.	300–550	7	0	1	0	3.3	0.0	1	0	3	0	14	0

Table 46 which follows deals with the vertical closing hauls. Considering both number of animals and frequency, the region of the plurimum during the day is between 100 and 200 fathoms, though the abundance at 200–250 is a little greater (lines 3 and 4). It is noticeable that above 40 fathoms (line 1) the abundance by night is greater than by day.

TABLE 46

Distribution of *Rhincalanus nasutus* as shown by hauls with the vertical closing nets, day and night hauls compared

	Depth	A Total hauls		B Successful hauls		C Total animals		D Animals per 100-f. haul		E Haul frequency	
		Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
1.	40–0	106	100	1	6	1	8	2	15	0.9	6
2.	100–40	39	34	7	6	12	10	20	16	18	16
3.	200–100	12	7	10	6	51	13	51	13	84	85
4.	250–200	6	1	5	0	26	0	52	0	16	0
5.	300–250	4	1	3	0	17	0	34	0	25	0

The result in tables 45 and 46, in connection with those of the surface hauls, are indicative of a movement of the greater portion of the individuals from the neighborhood of 200 fathoms upward to above 100 fathoms at night.

Scolecithrix persecans.—Two day hauls at the surface obtained three specimens. The species as a whole appears to be a resident of deep water during the day; it is rather common in the closing hauls, and an idea of its occurrence in hauls with the horizontal nets may be obtained from table 47, which follows. The table shows the plurimum is located between 200 and 250 fathoms during the day (line 4), and that that region is deserted during the night; on the other hand the animals were taken between 4 and 75 fathoms only at night (lines 1 and 2). This indicates that there is an upward movement at night.

TABLE 47

Distribution of *Scolecithrix persecans* as shown by hauls with the horizontal closing nets, day and night hauls compared

	Depth	A Total hauls		B Successful hauls		C Total hours		D Total animals		E Animals per 10-hr. haul		F Haul frequency	
		Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
1.	4–35	29	27	0	1	8.8	7.8	0	1	0	1	0	4
2.	50–75	12	8	0	1	3.3	3.0	0	2	0	6	0	8
3.	100–160	8	11	2	2	2.7	4.0	4	6	14	16	25	18
4.	200–250	9	3	3	0	3.2	1.6	6	0	18	0	33	0
5.	300–500	7	0	1	0	3.3	0.0	1	0	3	0	14	0

Table 48, which follows, deals with the vertical closing hauls. It will be seen that, as in the preceding table, the day plurimum is between 200 and 250 fathoms (line 4) and that this region and the level below (line 5) are deserted at night. The animals are more abundant above 100 fathoms by night, but the results are not particularly clear.

TABLE 48

Distribution of *Scolecithrix persecans* as shown by hauls with the vertical closing nets, day and night hauls compared

	Depth	A Total hauls		B Successful hauls		C Total animals		D Animals per 100-f. haul		E Haul frequency	
		Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
1.	40–0	106	100	1	0	1	0	2	0	0.9	0
2.	100–40	39	34	0	5	0	53	0	8	0	14
3.	200–100	12	7	9	5	184	37	184	37	75	71
4.	250–200	6	1	5	0	203	0	406	0	81	0
5.	300–250	4	1	3	0	74	0	148	0	75	0

Undeuchaeta bispinosa.—This species was taken at the surface only at night, when there were five successful hauls containing 25 animals; 21 of these were taken between 8 and 10 p.m., and two between 10 and 12. The temperatures for these hauls range from 18°9 to 20°2 and the salinities from 33.539 to 33.762. This is the only species which occurs at the surface consistently at any temperature (high in this case), there being a range of 1°3. In other cases the range is as much as six degrees. The hauls that contained *Undeuchaeta* are so few that its occurrence with reference to temperature is only suggested, but the available data are certainly exceptional merely in indicating conclusions as to the effect of that factor in determining the distribution of the species.

The distribution of this species as shown by the horizontal closing nets is set forth in table 49 which follows. The day plurimum is between 200 and 250 fathoms (line 4); this region is deserted during the night but the animals were taken between 4 and 75 fathoms only at night. These facts are evidences of an upward movement at night.

TABLE 49

Distribution of *Undeuchaeta bispinosa* as shown by hauls with the horizontal closing nets, day and night hauls compared

	Depth	A Total hauls		B Successful hauls		C Total hours		D Total animals		E Animals per 10-hr. haul		F Haul frequency	
		Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
1.	4–35	29	27	0	2	8.8	7.8	0	3	0	3	0	8
2.	50–75	12	8	0	1	3.3	3.0	0	13	0	43	0	12
3.	100–160	8	11	0	0	2.7	4.0	0	0	0	0	0	0
4.	200–250	9	3	4	0	3.2	1.6	12	0	37	0	44	0
5.	300–550	7	0	4	0	3.3	0.0	8	0	23	0	57	0

The vertical closing hauls are dealt with in table 50 which follows. The results are practically the same as for the horizontal closing hauls (preceding table) and need no further comment.

TABLE 50

Distribution of *Undeuchaeta bispinosa* as shown by hauls with the vertical closing nets, day and night hauls compared

	Depth	A Total hauls		B Successful hauls		C Total animals		D Animals per 100-f. haul		E Haul frequency	
		Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
1.	40–0	106	100	0	2	0	2	0	5	0	2
2.	100–40	39	34	0	5	0	8	0	13	0	14
3.	200–100	12	7	1	2	1	2	1	2	8	28
4.	250–200	6	1	3	0	44	0	88	0	50	0
5.	300–250	4	1	3	0	29	0	58	0	25	0

The evidence of all the nets is indicative of an upward movement of the animals at night.

Distribution of *Euchaeta tonsa, Euchirella galeata, Gaetanus unicornis, Pleuromamma xiphias, Scolecithrix frontalis* and *S. magna*

These six species were not taken at the surface in any of the hauls. For that reason I have considered them together. Table 51 shows the range of each of the species, but in the case of the vertical closing nets it is to be understood that "range" means

that the depths given are only *possible* limits. The number of each species and the number of successful hauls is given in table 13. The animals were not taken in hauls with the open vertical net starting above the depths given in table 32.

TABLE 51

Vertical ranges of six species that did not occur at the surface

Character of haul	Horizontal closing	Vertical closing	Vertical open
	Range in fathoms		
Euchaeta tonsa	160–300	200–300	150
Euchirella galeata	200–350	75–300	160
Gaetanus unicornis	220–350	150–350	250
Pleuromamma xiphias	10–350	40–350	100
Scolecithrix frontalis	100–350	50–300	150
Scolecithrix magna	250–350	100–300	290

In table 52 I have attempted to show how these species are distributed at different depths by day and night in the horizontal closing hauls. The actual numbers of animals for each species are given in the column at the left in columns C–H, and the species are designated by using the first letter of the generic and specific names. In the right-hand columns (C-H) are the numbers of specimens to be expected in ten hours of hauling; this avoids the use of numbers smaller than 1.

TABLE 52

Distribution of the six species that did not occur at the surface, as shown by the horizontal closing nets, day and night hauls compared

	Depth	A Total hauls	B Total hours	C *E. t.*		D *E. g.*		E *G. u.*		F *P. x.*		G *S. f.*		H *S. m.*	
	I. 6 a.m.-6 p.m.														
1.	4–35	29	8.8	0	0	0	0	0	0	0	0	0	0	0	0
2.	50–75	12	3.3	0	0	0	0	0	0	0	0	0	0	0	0
3.	100–160	8	2.7	0	0	0	0	0	0	1	3	1	3	0	0
4.	200–250	9	3.2	3	9	3	9	1	3	7	21	4	12	1	3
5.	300–550	7	3.3	7	21	1	3	3	9	4	12	6	18	2	6
	II. 6 p.m.-6 a.m.														
1.	4–35	27	7.8	0	0	0	0	0	0	3	3	0	0	0	0
2.	50–75	8	3.0	0	0	0	0	0	0	0	0	0	0	0	0
3.	100–160	11	4.0	1	4	0	0	0	0	0	0	0	0	0	0
4.	200–250	3	1.6	0	0	0	0	2	6	0	0	1	3	0	0

Table 53 which follows deals with the vertical closing hauls. It is similar to table 52, but the numbers in the right-hand columns (B–G) represent the numbers of animals per 100 fathom hauls.

TABLE 53

Distribution of the six species that did not occur at the surface, as shown by the vertical closing nets, day and night hauls compared

		A	B		C		D		E		F		G	
	Depth	Total hauls	*E. t.*		*E. g.*		*G. u.*		*P. x.*		*S. f.*		*S. m.*	
	I. 6-12 a.m., 4-6 p.m.													
1.	40–0	106	0	0	0	0	0	0	0	0	0	0	0	0
2.	100–40	39	0	0	0	0	0	0	0	0	0	0	0	0
3.	200–100	12	0	0	1	1	1	1	0	0	1	1	0	0
4.	250–200	6	5	10	8	16	6	12	16	32	18	36	3	6
5.	300–250	4	11	22	12	24	6	12	7	14	6	12	4	8
	II. 2-6 a.m., 6-8 p.m. (below 50 f.)													
6.	40–0	100	0	0	0	0	0	0	0	0	0	0	0	0
7.	100–40	34	0	0	0	0	0	0	1	2	15	25	0	0
8.	200–100	7	0	0	5	5	0	0	1	1	6	6	2	2
9.	250–200	1	0	0	0	0	0	0	0	0	0	0	0	0
10.	300–250	1	0	0	0	0	0	0	0	0	0	0	0	0

Consideration of tables 52 and 53 will show that there is some evidence of an upward movement at night on the part of these species which are all below 100 fathoms during the day. It is true that not all of the species were taken above 100 fathoms at night, but the general fact of decreased numbers below 100 fathoms at night in all cases and of increased numbers by day above 100 fathoms in some cases is suggestive. The number of all closing hauls above 100 fathoms during the day is many times greater than the number of night hauls, yet no animals were taken during the day above 100 fathoms. This evidence, it must be admitted, is unsatisfactory, yet tables 52 and 53 taken together at least suggest that the species which never came to the surface are found in deeper water by day than by night.

Our knowledge of the usual conditions under which these species live during the day is so slight that there is not even a suggestion to offer as to why they do not come to the surface.

GENERAL CONSIDERATIONS

In the preceding study of the distribution of nineteen species of copepods in as much detail as the data allow, the fact of greater abundance at night in the upper water has been prominent in the case of every species. From collections with closing nets we are able to locate the day plurimum or center of migration with a reasonable degree of accuracy, and this is never at the same depth for daylight hauls that it is for collections made during the night. The obvious conclusion is that there is an upward migration from the region of greatest abundance during the day to that during the night. For this reason the term "center of migration" as first used by Michael (1911) is particularly appropriate in referring to the region of the day plurimum.

The possible effect of the lack of as many night as day hauls in deep water in modifying this conclusion has been mentioned several times in the course of the paper, but it seems impossible that the widespread occurrence of the upward movement at night can be due to excess of day hauling. It is exceedingly desirable, nevertheless, to have more hauls with the closing nets at depths of 200 fathoms and below, and during the night especially.

The matter of upward migration at night is most evident in table 54 which deals with surface and closing net hauls, all separated into day and night and the latter into those above 100 fathoms or at this level and below.

TABLE 54

Numbers of animals at the surface, and above and below 100 fathoms, day and night hauls compared; horizontal and vertical closing nets considered separately

		No. of animals per 10-hr. haul in surface hauls		No. of animals per 10-hr. haul in horizontal closing hauls				No. of animals in 100-f. haul in vertical closing hauls			
				Above 100 f.		At or below 100 f.		Above 100 f.		At or below 100 f.	
		Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
1.	*Calanus finmarchicus*	68.0	2099.0	330.0	740.0	510.0	480	766	1187	567	202
2.	*Eucalanus elongatus*	61.0	270.0	310.0	120.0	620.0	170	296	290	1362	101
3.	*Euchaeta tonsa*	0.0	0.0	0.0	0.0	30.0	4	0	0	32	0
4.	*Euchirella galeata*	0.0	0.0	0.0	0.0	12.0	0	0	0	41	5
5.	*Euchirella pulchra*	0.1	2.3	0.0	5.0	87.0	0	0	21	154	8
6.	*Euchirella rostrata*	0.3	2.3	0.0	0.9	0.9	1	1	2	0	0
7.	*Gaetanus unicornis*	0.0	0.0	0.0	3.0	12.0	6	0	0	25	0
8.	*Gaidius pungens*	0.4	0.0	3.0	6.0	727.0	14	0	77	1377	58
9.	*Labidocera trispinosa*	28.0	462.0	.....	.....	.....	.....	.....	.....	.....	.....
10.	*Metridia lucens*	5.0	5487.0	150.0	560.0	41.0	140	690	1715	3035	534
11.	*Pleuromamma abdominalis*	0.1	54.0	3.0	60.0	73.0	31	0	18	141	7
12.	*Pleuromamma gracilis*	0.0	30.0	0.9	0.0	0.0	0	0	1	307	0
13.	*Pleuromamma quadrungulata*	0.3	0.0	0.0	7.0	127.0	22	0	0	375	17
14.	*Pleuromamma xiphias*	0.0	0.0	0.0	2.0	34.0	1	0	2	46	1
15.	*Rhincalanus nasutus*	0.9	6.0	7.0	1.0	12.0	2	22	31	137	13
16.	*Scolecithrix frontalis*	0.0	0.0	0.0	0.0	33.0	3	0	25	48	6
17.	*Scolecithrix magna*	0.0	0.0	0.0	0.0	9.0	0	0	0	14	2
18.	*Scolecithrix persecans*	0.9	0.0	0.0	7.0	35.0	16	2	8	738	37
19.	*Undeuchaeta bispinosa*	0.0	3.0	0.0	46.0	6.0	0	0	18	167	2
	Totals	165.1	8865.6	796.9	1557.0	2368.9	890	1787	3405	8546	995
	Total number of hauls	111	92	31	35	24	14	145	22	134	9
	Total number of hours	85.6	69.5	12.1	10.8	9.2	5.6	.....	.....	.....	.....

It can be seen in the preceding table that there are only three exceptions to the rule that the abundance at the surface is greater at night; these are, *Gaidius pungens, Pleuromamma quadrungulata* and *Scolecithrix persecans.* There are only nine animals involved for the three species and they are evidently individual exceptions, for each species is typically resident in deep water. *Eucalanus elongatus* in both sorts of closing nets and *Rhincalanus nasutus* and *Pleuromamma gracilis* in the horizontal nets were found less abundantly by night than by day above 100 fathoms; the other sixteen species were more abundant by night in the epiplankton. The species occurring at all below 100 fathoms were much more abundant there by day than by night, with the exception of *Metridia lucens* in the hauls with the horizontal closing nets.

It may be pointed out that, though the number of night hauls at the surface and above 100 fathoms is smaller than the number of day hauls, the number of animals is much larger at night at both levels. This makes it unlikely that the larger number of animals during the day at or below 100 fathoms is due to the larger number of day hauls.

The Copepoda appear to behave as do the Ostracoda as shown by Fowler (1909). He found that out of about fifteen species, nine showed an increase in the epiplankton at night, and three were never taken at or above 100 fathoms by day; one species was taken there once, another was taken twice. Six species did not show such a variation by day and night. Table 54 shows that out of nineteen species of copepods, six were never taken at the surface nor above 100 fathoms by day. There are fewer exceptions among the copepods to the rule of increased numbers in the epiplankton at night.

The facts regarding vertical distribution of the copepods of the San Diego region show, I believe, that each species is in a state of chronic movement as claimed for the ostracods by Fowler (1909, p. 299). The reasonable explanation of increased abundance at night above 100 fathoms is that the population is actually augmented by specimens coming up from below, especially since there is a decrease in the numbers of animals taken below 100 fathoms at night. The idea that we have to deal with

the oscillations of a confined swarm is without foundation, considering the length of time and the area over which our observations extend (Fowler, 1909, p. 304). Damas et Kofoed note (1905, p. 410) conditions among the copepoda, similar to those observed here.

Franz (1911b, p. 10) states that it is doubtful if vertical migration occurs regularly; the catches may be larger at night because the animals can not see the nets and are taken in larger numbers than during the day when the nets are visible. He says that if nets are constructed that tend to prevent the escape of the organisms the difference between the day and night catches diminishes.

The possibility that the animals see the nets and avoid them during the day should not be ignored, but it can not apply in the case of such organisms as the Halocypridae among the Ostracoda, which have no eyes (Fowler, 1909, p. 302). The fact of diurnal migrations is so well established for the Chaetognatha (Michael, 1911) and Copepoda of this region, and the Ostracoda of the Biscayan region (Fowler, 1909) that it is needless to more than mention those instances to indicate the extent to which such movements appear to occur.

Franz also (1911b, pp. 8 and 9) states, on the basis of his experimental work, that we may assume that copepods in their natural surroundings do not react phototactically, and he uses this, apparently, as an argument against the occurrence of diurnal migrations. On the contrary, he says the movements observed in nature take place because of unrest for short periods. Furthermore, he claims (p. 12) that his laboratory experiments have shown for a number of animals (among them certain pelagic copepods) that movements toward or away from a source of light do not take place because of unequal illumination, but because of the unusual and abnormal stimulation produced when the animals are put into the vessel.

In another paper this author states his views concisely (Franz, 1911a, p. 10), where he says: "Wenn die freibeweglichen Tiere beim Laboratoriumsversuch phototaktisch reagiren, so tun sie für eine etwas längere Zeitsdauer das, was im Freileben das Fliehen vor ungünstigen Einflussen oder das Aufsuchen geeigneterer Aufenthalts ist. Die Lichtsverhältnisse sind für die

Tiere im Freileben wichtige Wegweiser bei ihren Fluchtbewegungen, und deshalb dirigiren sie auch die Fluchtreflexe der Tiere im Laboratorium.''

''Die Phototaxis ist bei den untersuchten Tieren also nur als ein kleiner Ausschnitt aus den Lebensgewohnheiten zu verstehen.''

The author is justified in his claim that phototactic reactions are not in themselves vertical migrations. There can be hardly any doubt that the migrations take place, but it has been pointed out in the course of this paper, and elsewhere (e.g., Esterly, 1911b), that a negative reaction to light does not seem to explain *downward* movements. Reactions to light are, as stated by Franz (1911a, p. 10), only a part (possibly not small) of the habits of the organisms, but it is difficult to avoid the conclusion that a reaction to light is the primary cause of the upward movement. The results in table 55 appear to show that the copepods follow a waning light in their upward migration. We may assume that the optimum intensity of light is low, judging from the depth at which the plurimum of most species is located during the day, and that the animals follow the optimum, so to speak.

TABLE 55.

Total numbers of animals and numbers per hour in ten species at surface during different periods of the night; totals at left, averages per hour at right in each column; bold face indicates plurima. When the average falls below 1, it is not entered.

	Number of specimens							
	6-8 p.m.		8-10 p.m.		10-12 p.m.		12 p.m.-6 a.m.	
Calanus finmarchicus	3643	182.1	4285	**973.7**	3825	136	1842	44.7
Eucalanus elongatus	403	20.1	321	73.2	0		1175	28.2
Euchirella pulchra	12		3		1		1	
Euchirella rostrata	9		2		0		5	
Labidocera trispinosa	**2630**	**131.5**	3		0		569	13.8
Metridia lucens	1		228	52.0	**31900**	**11390**	6011	145.8
Pleuromamma abdominalis	45	2.2	**254**	**57.7**	14	5	57	1.3
Pleuromamma gracilis	1		**165**	**37.5**	15	5.4	32	
Rhincalanus nasutus	5		**14**	**3.2**	0		6	
Undeuchaeta bispinosa	1		**21**	**4.8**	2		1	
Totals	6750		5296		35757		9699	
Total hours of hauling	20		4.4		2.8		41.2	
Number of animals per hour haul	328.5		1203.6		12770		230.3	

There is only one case (*Eucalanus elongatus*) where the two plurima do not coincide.

Table 55 shows that three species were at their plurimum between 6 and 8 p.m., five between 8 and 10 p.m., one between 10 and 12 p.m., and one between 12 p.m. and 6 a.m. As to totals, the period from 10 to 12 p.m. is overwhelmingly predominant owing to one haul of *Metridia lucens* that contained 32,000 specimens. The number of hours of hauling between 8 and 10 p.m. and 10 and 12 p.m. are small compared to the time from 6 to 8 p.m. or from 12 p.m. to 6 a.m., but the numbers of animals per hour are much larger for the shorter times. This is to be expected, but the totals of those times are so high that it is to be presumed that the averages would be at least relatively as large if there had been more hauls.

All species do not have the same time of maximum abundance at the surface as shown by table 55, but in eight cases out of ten it occurs between 6 and 10 p.m. On the whole, there is no reason to doubt that table 55 gives an approximately correct idea of the time of greatest abundance at the surface for the species considered.

I have been unable to find that there is any clear relation between the distribution of the Copepoda of this region and temperature and salinity of the water. It may be said that the expectation was that such a relation would appear, especially in view of the results of Michael with the Chaetognatha. This investigator is of the opinion (1911, p. 160) that a species is a species as much from the physical environment in which it is normally found as from its morphological characters. Hjort, also (1910, p. 371), states that each of many forms in the same area of the sea has its own area of distribution, mode of life and habitat, and that a species may be defined by certain conditions of existence as well as by its structure. "These conditions characterize a given species quite as much as any morphological description, and in fact for a proper conception of the species both methods of investigation are supplementary."

The available data for the Copepoda of this region lend plausibility to these views, at least to the extent of showing that a species is not characterized by structural features alone. No

two kinds of copepods so far as can be determined, have the same behavior, as is shown by the fact that the curves in figures 1–7 are all different. While the amount of data is small in some cases, it shows that a species may be recognized by its behavior as well as by its structure. We do not know enough about the conditions under which these forms live to be able to state, as Hjort does in the passage mentioned, that each has its own area of distribution, but we can say that the character of a species is shown by something else than its morphology.

There is another point that should be mentioned here. If we start with the species as defined by *structural characters,* can it be shown that, on such a basis, the range of the form is limited by definite hydrographic conditions? In other words, is there any evidence that each species has its own area of distribution or not?

There is some tendency to argue that if a certain form is found within a given area we may *expect* to find morphological characters that distinguish these forms from others. For example, Nordgaard (1905, p. 243) cites instances of the division of a species into two or more because of "more exact morphological investigation" (the morphological investigation apparently being subsequent to hydrographic studies) so that "instead of one species distributed over nearly every sea we now get three species with a comparatively limited distribution." The species referred to in the quotation is *Calanus finmarchicus,* and I have already mentioned that there is some difference of opinion regarding the validity, on morphological grounds, of one of its derivatives. The question here, however, is whether or not within such an area as that under investigation by this station each species, or even a group of species, may be said to have a physical environment of its own.

So far as the study of the copepods in the San Diego region has gone, there is no evidence that they form "hydrographic" species. *Calanus finmarchicus* has been taken at the surface in as great numbers when the temperature is as low as it gets, as at the highest temperatures and those between the extremes. This species, like all the others, has a plurimum or center of migration for the day and also for the night, but there is no reason to

claim that a given temperature or salinity of the region most frequented during the day is any more of an optimum (so far as those physical factors are concerned) than is the temperature of the region of most abundance during the night. In other words, a species like *Calanus finmarchicus,* in its extensive diurnal migrations probably passes back and forth through as many different physical conditions as would be encountered in a horizontal journey of many miles at a given level.

As our knowledge of the temperature and salinity conditions of the waters of this region increases, it may be that we shall find that there are regions for certain species with bounds that are definite, within which the species may be said to be isolated. It seems to me, however, that the body of facts presented here concerning vertical migrations is no small indication that the boundaries are not temperature or salinity lines, even if it shall be found that boundaries of some kind actually exist.

It is true that maps have been made showing the distribution of certain species of copepods. Damas (1905) has done this for the larvae and adults of *Calanus finmarchicus* and Farran (1910) for a number of species. Both these investigators have dealt with region which are affected by great ocean currents, where there are, accordingly, barriers due to abrupt changes in temperature. It is possible, therefore, to delimit the regions occupied by given species more or less sharply. The San Diego region, however, seems not to present such conditions, and, as far as we know, changes in temperature and salinity are gradual. Six species of copepods were never taken at the surface, but there is no evidence that they avoid the surface because of the temperatures or salinity there. We know that each of these species appears to execute diurnal migrations, and in so doing it is presumable that they encounter changes of temperature and salinity. We do not know how great the changes are. It must be admitted that there are temperatures or salinities which would act as barriers, but so far as our investigations have gone they do not seem to occur in this region. The probable reason that temperature has no apparent effect in such a case as that of *Calanus* is that a variation of from 16°–20° at the surface is too small to cause an appreciable reaction when an organism

encounters, during vertical migrations, a range from 7° or less to 20° or more. The same sort of statement applies to salinity.

At the present stage of our investigation (so far as the Copepoda are concerned) it seems that differences in temperature and salinity must be either more considerable or more abrupt than we have yet found, if we are to be able to speak of "copepod provinces" in this region. On the other hand, changes in light intensity are periodic as well as gradual, and it seems that those are the changes which influence the distribution of the copepods. We cannot claim that the temperature changes with the time of day (to any important extent, at least) and I feel more strongly than ever that light is the main determining factor in the vertical distribution of these organisms. It is only too plain that this is not the whole of the matter, but it is certain that, through the widespread occurrence of day and night oscillations, we have recognized a factor that is important. In view of our results at this station statements as to the depth limits of copepods should be based upon day or night hauls separately. That is, if a species is not found above 100 fathoms during an expedition when collecting at that level is done only during the day, it does not follow that the usual hydrographic conditions at or below that level are the optimum conditions for the species. The same form would probably be found at night above 100 fathoms where the hydrographic conditions are almost certain to be different from those met with during the day hauling.

The foregoing discussion should be regarded as more in the line of suggestion than exposition. It is based entirely on the results of studying collections as embodied in this paper, and is not intended as a criticism of the views of others. That would be warranted only when our collections are much more numerous and especially when we know the sub-surface temperature and salinity conditions under which a large series of hauls with the Kofoid horizontal closing net were made.

Our results hardly warrant more than the mention of their apparent bearing on the question of coincident distribution of related species. The hauls, especially with the Kofoid net, in which "couplets" of species occurred are so few that I can cite only a few *instances* (which are notorious for proving anything).

The general trend of the data concerning the distribution of the Copepoda is in line with the discussion in the papers of Kofoid (1907a, 1907b). He shows for a number of plankton animals that in general the species which are more closely related structurally have a coincident instead of a contiguous distribution. This might also be inferred as true of the pelagic Copepoda, since so many of them are found at the same depths during the day. As particular examples may be mentioned *Gaetanus unicornis* and *G. secundus,* which, structurally, form a very closely related pair of species; *secundus* was taken in but one haul with the Kofoid net, but then it was in company with a specimen of *unicornis.* *Euchirella galeata* and *E. pulchra* form a couplet: the former was taken in but three hauls with the Kofoid net, always with *pulchra.* *Scolecithrix magna* appeared in but three hauls of this character, two of which contained *S. frontalis,* a rather closely related species. The four species of *Pleuromamma* found in this region occurred together repeatedly in the closing nets and *P. abdominalis* and *gracilis* were taken together in the seven hauls that contained *gracilis.* It is hard to say how much these examples mean until we know more about breeding ranges and seasons as well as the general hydrographic conditions in deep water, where all of the species mentioned are found in greatest abundance during the day.

It is important to note again, however, that, even with our lack of knowledge concerning the conditions under which the Copepoda live, the forms we know most about show differential characters in other respects than structure. The species grouped in the "couplets" mentioned above are so placed because of morphological characters. If our knowledge of them in other matters were as extensive we might find that they are examples of species that are quite *different* from each other but with a similar distribution. That is, if the behavior, for example, of one species of *Gaetanus* should prove to be markedly unlike that of the other, there would be justification for the view that these are distantly related forms; and even if they should always be taken in the same hauls with the Kofoid net, it would at least be a matter for argument if they were not examples of the coincident distribution of distantly related species. That would depend on

what conditions are held to be the more important in the characterization of species. As a matter of fact the species mentioned in the above speculation are two that we know practically nothing about (except as to structure), yet they may be used to illustrate the different points of view that are possible in the matter of "coincident *versus* contiguous distribution."

The interesting matter of color of marine animals and the depths at which they occur has recently been discussed by Hjort (1911). It was found on the "Michael Sars" expedition that black and red forms predominate among animals from greatest depths (Hjort, 1911, pp. 503, 504), and in certain cases all the specimens of fishes caught above 150 m. were taken at night (p. 505). Hjort states (p. 505) that the rays of light will have passed through the same distance to reach a depth of 500 meters in 50° N, that they will pass through to reach 650 meters in 33° N, or 300 meters in 67° N. The visible depth in the open sea is given as 50 meters in 33° N, 40 meters in 50° N, and 25 meters in 67° N. As to the intensity (p. 506), it will be the same from rectilinear rays in 33° N at about 200 meters, at 50° N at about 500 meters, and at 67° N at about 200 meters. The red and black forms therefore have an upper limit in different waters which corresponds everywhere with the same intensity of light. The upper limit for the red crustacea at about 50° N was 500 meters below the surface, while for the same forms at 33° N it was from 200 to 300 meters deeper.

The distribution of the copepods of this region is in general line with the observations of Hjort. Many of the typically deep water forms are characterized by red or orange in the body as a whole or merely in localized regions. Such are the species of *Euchaeta* like *tonsa;* of *Euchirella* such as *galeata, pulchra, simplex, propria, truncata; Pleuromamma quadrungulata;* others might be given as examples of deep water forms that have red or orange-red pigment. On the other hand there are species with a similar range which are exceedingly transparent, such as *Augaptilus lucidus* or *pyramidalis;* the former has a brown spot around the mouth while the latter is entirely without pigment. It is hardly necessary to mention *Calanus finmarchicus* or *Eucalanus elongatus* which have been taken as deep as 400 fathoms with the

Kofoid net, the latter even appearing in a haul at 550 fathoms; these species, however are not as thoroughly characteristic of deep water as the others, nor do they possess as much red pigment. There is only only black copepod known from this region, *Metridia atra*, which was taken with the Kofoid net at 550 fathoms.

Hjort (p. 507) evidently inclines to the opinion that red animals are protected by the color in deep water, for the red rays were not found at 500 meters by means of the Helland-Hansen photometer, and red animals at that depth must be as invisible as black ones.

The available data concerning the distribution of the Copepoda of this region are not extensive enough to make a discussion of this question advisable. It may be pointed out, however, that the upper limit for red animals as given by Hjort for this latitude (700–800 meters or about 435 fathoms) seems to be farther down than our data would lead us to believe. The extreme limits within which the largest numbers of individuals are taken are 200 and 400 fathoms, but horizontal closing hauls below 350 fathoms are greatly needed to determine this point more satisfactorily. The general fact of the red forms being taken at much higher levels during the night than during the day is most evident, as shown also by Hjort (1911, pp. 503 and 504). He states, however, (p. 509) that out of 3600 transparent larvae and young fishes, 90 per cent were taken between the surface and 150 meters. We find that transparent copepods (such as *Eucalanus*) are obtained at practically all depths, and it certainly seems that a transparent form would be as invisible at 400 fathoms as anywhere else. This whole matter is an exceedingly important and interesting one and well worth further study; at this time such suggestions as have been given above and elsewhere (Esterly, 1911a) are all that are warranted.

I have not found that our data indicate that there is a relation between the locality in which a haul at the surface is made and the abundance of any of the species. Likewise, there is nothing to be noted as to the seasonal distribution. Possibly this is because the greater portion of our collecting was done in June, July, and August.

In conclusion, I do not wish to be understood as having

advanced any views that I regard as more than tentative, although the data as analyzed lend strong support to the suggestions that have been made. Michael has well expressed my feelings in his concluding paragraph (p. 160) as to proving conclusions. I feel as he does, also, in regard to the necessity of improving our methods of collecting, especially as to the use of similar nets at all depths. From my experience up to this point, I feel that one successful haul with the Kofoid net is more valuable than many with the vertical nets. We need, also, more hauls of that sort at night and especially between 25 and 150 fathoms; day and night hauls at 200 fathoms and below would also tend to clear up some obscure points.

I wish to express my appreciation of the many favors extended to me by Professor W. E. Ritter, Director of the La Jolla station, and by Mr. E. L. Michael, the Resident Naturalist, and particularly of the friendly and helpful conversations with them My wife has patiently helped in the tiresome drudgery of making tables and checking results; hers is no small part in that portion of the work.

SUMMARY

1. The Copepoda as a group are found mainly in deep water during the day, the upper limit being not above 150 fathoms; the region of greatest abundance on the whole is probably about 250 fathoms.

2. It is the rule, practically without exception, that the abundance is greater at higher levels during the night than during the day, and that such deep water forms as come to the surface do so mostly at night. In other words the epiplankton is more populous at night, the mesoplankton during the day.

3. Thus there seems to be a constant oscillation of these Crustacea, there being a day and a night plurimum or "center of migration." If we may take it for granted that the region of greatest abundance is located where the largest number of optimum conditions are found, the fact of diurnal movement suggests that the optimum is a rather indefinite term since it changes with the time of day.

4. This fact of constant change appears to make it doubtful if there are regions in which species may be said to be isolated. At any rate the data available from the records of this station do not show that the abundance of any of the species is related to temperature or salinity. These have been taken for the surface hauls only, as yet, and the species of Copepoda that we know most about reach the plurimum at the surface at night regardless of the temperature or salinity within the limits known for the region.

5. On the other hand, no two of the curves of distribution at the surface with regard to time are the same, so far as the more abundant species are concerned. This fact suggests that, just as there are structural differences between the forms, there are also other characters that mark a species as a definite kind. It is also to be suggested that, though two forms may be closely allied structurally (so far as we can judge), and taken repeatedly in the same area, the other differential characters will show that the forms in question occur coincidently as widely separated species.

6. Ten species have been taken at the surface in large enough numbers for judging as to when during the night they reach their maximum abundance. Three species do so between 6 and 8 p.m., five between 8 and 10 p.m., one between 10 and 12 p.m., and one between midnight and 6 a.m. (table 55).

7. *Calanus finmarchicus* is the commonest species in the San Diego region. The following conclusions as to its distribution and behavior appear to be well grounded:

(*a*) With the surface nets (tables 12 and 13 and fig. 1) we found that it is most abundant during the night, between 10 and 12 p.m., though there is a very marked increase in abundance beginning at 6 p.m. After midnight there is a great decrease in the size of the hourly averages.

(*b*) With the Kofoid closing net we found (Esterly, 1911b, tables 4 and 5) that the day plurimum is at 200 fathoms; that the evening plurimum is at 100 fathoms; that at midnight the plurimum is at 5–10 fathoms; and that from 4 to 6 a.m. the plurimum is again at 100 fathoms.

(*c*) With the vertical closing nets, we found (tables 14 and

15) that the plurimum is at 75–50 fathoms for the day, though the animals were taken in a few more than half of the hauls at that level, while from 150–250 fathoms all of the twelve hauls were successful. At night there are two plurima, at 10–15 and at 30–25 fathoms.

(*d*) All the nets agree in indicating that there is an upward migration at night, though this is shown more clearly with the surface and horizontal closing nets.

(*e*) The animals appear to leave the surface before the light increases at all in intensity. This suggests that decreasing light is not the cause of the downward movement. A more complete discussion of this question will be found in my paper mentioned in (*b*) above.

8. In regard to the distribution of *Eucalanus elongatus,* the next most abundant species, we found:

(*a*) With the surface net (tables 21 and 22 and fig. 2) that the animals are more abundant at night; that the highest average per hour for any two-hour period is between 8 and 10 p.m., though the number per hour for the six hours of the night before midnight is much smaller than for the six hours after midnight; that there are three plurima for the occurrence of the species on the surface (fig. 2), in the afternoon, evening and morning. On the whole, the occurrence of *Eucalanus* is erratic, as compared with that of *Calanus.*

(*b*) With the Kofoid horizontal closing net we found that there is an extensive movement of the species from a day plurimum at 200 fathoms, which does not seem to come under the class of diurnal migrations (Esterly, 1911a).

(*c*) With the vertical closing nets we found (tables 23 and 24) that the day plurimum is probably at 200 fathoms as an average depth; that the abundance and frequency above 50 fathoms are greater by night than by day, while below 50 fathoms the reverse is the case.

9. The distribution of *Metridia lucens* shows the following features:

(*a*) With the surface net (tables 26 and 27) the greatest abundance and frequency is between 10 p.m. and 2 a.m.; that the hourly average is enormously larger between 10 and 12 p.m.,

though shown by only one haul; that, allowing for this condition, there is clear evidence of a regular diurnal migration.

(*b*) With the horizontal closing nets (tables 28 and 29) the day plurimum is shown to be at 100–160 fathoms; from 6 p.m. to 2 a.m. it does not go lower than 12 fathoms, but between 2 and 6 a.m. it is at 100–160 fathoms.

(*c*) With the vertical closing nets we found (tables 30 and 31) that there is evidence of diurnal migration, the day plurimum being between 200 and 150 fathoms, while at night it is at 100–75 fathoms.

10. The following species did not come to the surface: *Euchaeta tonsa, Euchirella galeata, Gaetanus unicornis, Pleuromamma abdominalis, Scolecithrix frontalis, Scolecithrix magna.* As a group, these six species are most abundant below 200 fathoms during the day and above 200 fathoms during the night (tables 52 and 53).

11. The other ten species (*Euchirella pulchra* and *E. rostrata, Gaidius pungens, Labidocera trispinosa, Pleuromamma abdominalis, P. gracilis* and *P. quadrungulata, Rhincalanus nasutus, Scolecithrix persecans, Undeuchaeta bispinosa*) were taken at the surface, but in so few hauls that an extensive analysis of them is not practicable. So far as the evidence goes, they are, with three exceptions more abundant at the surface at night, as can be seen in table 55. The exceptions are nine animals belonging to three species and there is nothing whatever to show why they should be found at the surface. The hauls with the closing nets show that these species, like the others, move upward during the night, as may be seen in summary in table 54.

Transmitted February, 1912.

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